LEARNING TO DRAW

OR THE STORY OF A YOUNG DESIGNER.

Gift to the B. Y. U.
by
Annie L. Gillespie.

H. S. Gillespie

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OR

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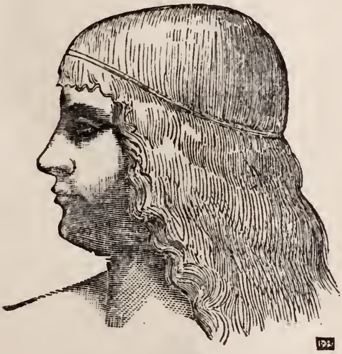
BY VIOLLET-LE-DUC

TRANSLATED FROM THE FRENCH

BY VIRGINIA CHAMPLIN



ILLUSTRATED BY THE AUTHOR

NEW YORK & LONDON
G. P. PUTNAM'S SONS
The Knickerbocker Press
1888

Press of
G. P. Putnam's Sons
New York

PREFACE.

THIS volume was the last written by its distinguished author, and has, in fact, been published since his death.

It is peculiarly characteristic of his comprehensive method of instruction; and, while starting from so simple a text as a child's sketch of a cat, it embraces in its moderate compass a very wide range of information, all of which is shown to belong to a proper comprehension of the business of learning to draw.

Le Duc maintained that the perceptive faculties must be thoroughly developed and cultivated before it is possible to know whether or not the student possesses any creative power. He insisted, further, that it is possible to cause art and what is admirable in man's handiwork, as well as the beauty of God's creation, to be comprehended by undeveloped as well as by educated minds; and this belief formed the keynote of much of his life's work. With this end in view he addressed himself with as much earnestness to young students as to *savants*, and always took pains to find the simplest methods of expressing the instruction he had to give.

The especial feature of this instruction, whether in his books or his lectures, is its suggestiveness. He interested himself in

showing the connection between one study and another; and, while the compass of his books did not make it possible for him to follow out exhaustively the various trains of investigation suggested, the path for the student is clearly indicated; he is taught how to analyze and compare, and above all to be satisfied with nothing but the highest standard and the most thorough work. M. le Duc is never tired of insisting that no special result can be successfully attained unless the work for it rests on the broadest possible foundation. The technical knowledge of the art must be preceded by the wider knowledge of methods of study, and of the relation of things to each other. Especially does he delight in pointing out the relations of man's handiwork to the creations of nature; and before either the general or technical knowledge comes the training of the perception, the learning to see, and to understand what is seen.

The young hero of this narrative is thoroughly educated as to his perceptions and judgment, and is then left free to decide what work his faculties best fit him for.

He chooses the profession of a designer; and his experience in preparing himself for his occupation should therefore be of special value to the many American students who are beginning to interest themselves in the work of introducing the principles of art into the environment of American households.

Teachers of art, both general and technical, and, for that matter, teachers of any subjects, will find this volume of Viollet-le-Duc of no little service in suggesting methods of instruction. It shows how students, young or old, are to be inter-

ested ; how all the surroundings of daily life contain suggestions for the most interesting and important lines of investigation ; how students are to be taught to think out processes for themselves, and to develop their powers of comparison and reasoning ; how the study of art of necessity leads us back to the study of nature which underlies all art ; and how, as before said, the basis of all education must be perception, so that learning to draw well and learning to do any thing properly depends upon first learning to see correctly.

Behind all the attention to detail, there is apparent in this book, as in all the works of Viollet-le-Duc, a love of truth for its own sake, and an insistance that this must be the aim of all work, whether artistic or technical.

That the volume may prove of service to American students and teachers, and may do its part in the development in this country of the true principles of art-education, is the hope and belief of

THE TRANSLATOR.

CONTENTS.

LEARNING TO DRAW;

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CHAPTER I.

TWO FOSTER-BROTHERS AND A CAT.

LITTLE André lived in the city, while his foster-brother Jean lived in the country; and both were nearly eleven years old.

It so happened that each delighted in drawing on the walls with a piece of charcoal. Whether they owed this inclination to scrawl on the walls to having a common nurse, or to chance, is a question I will not attempt to answer, but will simply state that each had this fancy.

André's father was a distinguished professor, who had had the honor of seeing several of his works crowned by the French Academy. Jean's father was a gardener by trade, and also a trellis-maker, and, when necessary, a carpenter; and yet all these trades united barely enabled

him to support his family, which was composed, to be sure, of six children, — four boys and two girls, — besides his mother and his wife.

Mellinot was the name of the father of André, who was an only son. M. Mellinot, besides his salary as a professor, inherited a moderate fortune, and gave private lessons, which were very profitable; so he was in comfortable circumstances, could give a dinner to his friends once a week, and lead a life free from care. He was a methodical man, of excellent principles and of a gentle disposition, and was greatly beloved and respected.

Mme. Mellinot was a worthy companion to this worthy man, and did not suppose that there existed in the whole world a mind superior to that of her husband; therefore there was not a day that she did not cast a look of tenderness mingled with a certain pride at the gilded frame surrounding the four or five medals and the academical crown awarded M. Mellinot, who needed only the cross of the Legion of Honor to achieve his highest ambition, and to render Mme. Mellinot the happiest of women.

As for Jean's father, as a gardener, he answered to the name of papa Ricin; as a trellis-maker and carpenter, to that of Pas-commode; but his real name was Loupeau, and he was a native of Boissy-Saint-Léger. Now, Loupeau was a rude workman, rather difficult to get along with, and a man whom it was not prudent to offend.

There was not much to be said of his wife, Euphrasie,

other than that she was the mother of six children, born at intervals of fifteen or eighteen months.

During the fine season, M. and Mme. Mellinot and André often went to spend Sunday in the woods of the Grange, and called on Euphrasie, with whom they would leave some wearing-apparel for her children, a pie, or a piece of roast meat, and a nice bottle of wine, in return for a luncheon of cakes and cheese; then they would go on to the pretty village of Yères to dine, whence the omnibus conveyed them to Villeneuve-Saint-Georges, where they took the cars, and reached home at about eleven o'clock in the evening.

André and Jean, either on account of a natural sympathy and similarity of tastes, or because they had the same nurse, were very good friends; and the Mellinots often took Jean with his oldest sister into the woods of the Grange, where they remained till dusk, when the brother and sister would return to Boissy-Saint-Léger.

Many ideas pass through the minds of children about which parents do not concern themselves; which is wrong.

The two foster-brothers, in their walks through the woods, talked of nothing but the drawing of men, horses, carriages, and houses.

Naturally André did not fail to bring the pictures which he drew during the week, — very simple copies of bad engravings of soldiers and odd palaces; and Jean, who admired them, asked for paper and a bit of pencil to do

some like them, which request André readily granted. On the following Sunday, Jean in turn showed his attempts. But the little fellow had no models; and in some corner of the house, hidden from papa Ricin, who would not allow his heir to scrawl over a sheet of paper on which could be made out a bill for labor, he would sketch something which André willingly corrected: for André probably inherited a taste for professorship from his father; moreover he was surrounded by art, and was sometimes taken on Thursdays to exhibitions.

When they seated themselves on the grass, M. Mellinot deigned now and then to cast a glance, first at André's work, then at Jean's; but, although any thing but an artist, he declared with very natural satisfaction that his son's precocious talent was evidently superior to that of his foster-brother.

One Sunday, however, a friend of the professor joined the ramblers; and this new character we will at once introduce in a few words.

M. Majorin was a tall, thin man, with a grayish beard, and always dressed in the same style; namely, a black coat (which hung from his shoulders as if from a clothes-rack), narrow pantaloons, and light-colored gaiters. In winter he wore a melon-shaped broad-brimmed hat, and in summer a soft gray felt. His linen was always spotless; and under his turn-down collar was fastened a cravat of white foulard. He seemed like an absent-minded man,

and took part in the conversation only when it rose above the commonplace; and when he talked he had the deplorable habit of expressing his thoughts freely and unguardedly, without caring to know if he wounded the feelings of his hearers. Therefore he was rather dreaded; and although M. Mellinot esteemed him as a precious friend, because he gave him advice that was useful to him in his career as a professor, Mme. Mellinot held him in horror, as one of those troublesome, eccentric men, who, without giving warning, fling a pebble into a pond, and spatter you.

This Sunday M. Mellinot was sitting among the ferns, under a beautiful oak, enjoying the cool air, and listening to Mme. Mellinot, who was entertaining him with the troubles between herself and the cook that morning before their departure. M. Majorin was lying full length, looking up into the blue sky through the foliage gilded by the sun, which is always a novel sight; while Jean's sister was hunting for strawberries, and the two foster-brothers were having a lively conversation a few steps distant.

"That's not the way to do it," said André.

"But that's the way I've seen it," answered Jean, who seemed to be no longer a pupil, but to have openly rebelled.

"We will see," said André finally, since he evidently could not convince Jean. "This is not the way to draw a cat; is it, papa?"

"Let me see it," said his father. André handed M. Mellinot a piece of crumpled paper, on which was pencilled the following sketch: —

Little Jean's Drawing.

"If it is intended for a cat, it's a cat with two paws. And what's that growing out of the top of his head?"

"That's his tail," answered Jean timidly.

"Oh!" said M. Majorin, rousing himself from his revery: "let me see it."

He looked attentively at the cat and at Jean; so that the latter blushed, and hung his head, and really did not know what to do with his hands, which embarrassed him very much.

"How old are you?" asked M. Majorin.

"Eleven years old on All Saints' Day, sir."

"Do you go to school?"

"Yes, sir, when papa does not take me to pluck weeds from the gardens of the *bourgeois*."

"Do they teach drawing at your school?"

"No, sir. They teach us to make only rounds and squares, and those not often."

"And does it amuse you to make rounds and squares?"

"Not very much."

"You prefer to draw cats?"

"Yes, sir."

"Where did you draw this?"

"On the steps of the house, where I was sitting."

"And what was the cat doing there?"

"He was turning round like that, looking for something."

"And you begged him to stop in front of you to have his picture taken?"

"Oh, no, sir! He wouldn't have done it."

"Then, how did you manage to draw him?"

"I looked at him as he came up to me very slowly, as if he were going to ask me for something to eat, for I was taking my luncheon; and he looked so funny,—oh, so funny!—just like a real person. I looked at him, and didn't laugh, because cats don't like to have any one laugh at them. I watched him, and he watched me; then I took a paper, and the pencil André gave me, out of my pocket. But, when the cat saw them, he ran away. Then, remembering just how funny he looked, I drew him on the paper."

"But you know very well that cats have four paws."

Jean did not answer.

"Why did you draw only two?"

"Dear me, sir! I didn't notice, I didn't see the others."

"Come, give me a kiss."

If this abrupt conclusion surprised Jean, it astonished M. and Mme. Mellinot even more.

"Will you give me your cat?" resumed M. Majorin.

"Oh, yes, sir! I'll draw others."

M. Majorin was visibly moved. They continued their walk, and the children ran into the woods.

"If I had a boy like this little fellow!" said M. Majorin almost involuntarily, after a long silence.

"Is it because he drew a cat with two paws, and a plume on the top of its head, that you express this desire?" responded M. Mellinot.

"No: because he was born an observer, and because this quality, or faculty if you will, permits one to advance, and, above all, to avoid many foolish mistakes."

"I do not understand why, to tell you the truth, one should draw a cat with two paws."

"No, you do not understand; or rather you, like many others, have seen only with the eyes of those who do not know how to see.

"To you a cat is a feline with four paws, a tail, two prominent flexible ears, and whiskers. If one should omit to show you a part of this inventory, you would not acknowledge it to be a cat. The little fellow does not care much about that: he did not see a mass of poor images pretending to represent complete cats, but a cat in a certain position which struck him, and he seized the principal features of the position. Being seated, he did not see the back of the animal, which was hidden from him by its head, and the tail appeared without any intervening part.

"His attention was not attracted to the hind-paws which were almost entirely concealed by those in front, and he did not see either the belly or the flanks. His eye in a few seconds seized the principal lines and the appearance of the animal, and his unskilled hand rendered what his eyes communicated to his understanding. Ah! little Jean may become a great artist."

"Perhaps: if Loupeau, the good man, could devote about twenty thousand francs to have him taught drawing, and pay his expenses at the School of Fine Arts.

"Yes," resumed M. Majorin, becoming animated, "if he could devote about twenty thousand francs to make that child lose his natural talent, — a precious gift that he unconsciously possesses, — and if he could devote forty more to give him time to unlearn what is taught him in your schools, and to see for himself."

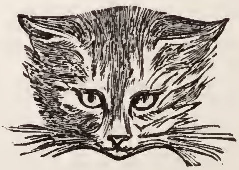
"Then, all that is to be done is to let matters alone, and Jean will of himself become a great artist."

"Ah, no! there's the difficulty. It is necessary to have a very thorough and broad education to develop the intellectual qualities, whatever they may be; and it is also necessary to work a great deal, but not by turning one's back on the end, in order to advance in about twenty or twenty-five years only so far as to vegetate in mediocrity, or to recognize that every thing is to be begun anew."

"My dear friend, France possesses a sufficient number

of young and distinguished artists to make one believe that those who receive a 'divine afflatus' attain their aim, and are not, as you claim, diverted from it. Besides, it is not from a scarcity of artists that we suffer: there are, indeed, too many; and in order to create them there is no need to encourage all whom certain precocious inclinations make one suppose, and wrongfully sometimes, to be capable of marking out for themselves a brilliant career. I distrust little prodigies, and I have too often seen them fail for want of prudence in their education. You become over-enthusiastic about a cat drawn in a certain way by a *gamin* ten years old; but was it not done by chance? Was it really from his own experience in observation? Did he not rather make a sketch from some artist's caricature pencilled on a wall?"

"Perhaps," M. Majorin simply answered; and nothing more was said that evening about little Jean and his cat.



CHAPTER II.

M. MAJORIN MAKES A STRONG RESOLVE.

INDISPUTABLY and rightly was M. Majorin regarded as an original character; for he not only disliked beaten tracks, but preferred to make his path through by-ways, heedless of briers and bogs. Therefore he had never been very far, but was perfectly well acquainted with the country he had traversed. To speak without metaphor, he was neither a prefect, a senator, nor a deputy, neither a judge nor a magistrate, neither a councillor of state nor a member of any academy: he was simply the manager of a factory in the suburbs of Paris, and he devoted his leisure to the study of the sciences and arts. No one was better informed in modern attainments. He was a skilful draughtsman, and spent his Sundays rambling through the fields, studying the rocks, making sketches, and botanizing. In his youth he travelled a great deal, and owned a large number of drawings which he never showed, but which comprised, upon the

whole, a very interesting collection relating to public buildings, geology, and the various branches of natural history.

He was a philosopher whom one might believe inclined to misanthropy, although he had a warm heart; but he had such a horror of the commonplace, that his habits of life seemed to be the result of a feeling of hostility towards the human race.

A few days after the little scene which we have just related in the preceding chapter, M. Majorin mounted his mare early one morning, and rode to the house of M. Loupeau at Boissy-Saint-Léger. The gardener-trellis-maker-carpenter was taking his soup, surrounded by his children, while dame Euphrasie was attending to household duties.

After fastening his horse to the back of the wooden bench by the door, M. Majorin entered a room which was both a kitchen and a sleeping-room, and, seating himself, without further ceremony said to M. Loupeau, —

"Do you recognize me?"

"Faith, I should think so! Aren't you the gentleman who came with our *bourgeois*, M. Mellinot, last Sunday?"

"Certainly. My name is Majorin; and it is I who carry on the manufactory at Hay."

"Ah, yes!"

"I have come to ask you if you can trust your boy, little Jean, to me."

"To tell you the truth, sir, I would rather have the boy

work with me than in the factories: it is not healthy, and, the more the little fellow grows, the more he can help me; and then a child, you understand, cannot be lent like a tool. His mother would not like it."

"I do not mean any thing of that kind. I do not intend to have Jean work in the factory, where we do not admit children, but to have him with me, and to teach him. I am a bachelor, and I shall treat your little one as my son. If, at the end of six months, I find that I can do any thing with him, I shall continue to take care of his education: if not, I shall bring him back to you. Will that suit you?"

"Bless me, sir! you know, all this you tell me isn't quite clear. With all respect to you, it is not a business-like way of doing things. What do you wish to do with the little fellow?"

"To do with him! why, teach him."

"But he can be taught almost well enough at school."

"Come, I offer to educate Jean at my expense till he reaches his majority, that is, if after a trial of six months I find that he can profit by this education. In event of my dying before his majority, well, I will agree, after the six months' trial, to leave him eight hundred francs income in government bonds, or settle on him a capital of twenty thousand francs. If I live till he reaches his majority, I shall have given him a profession by which he can earn a handsome living, enough to help you in your old age. What objections have you to make to that?"

"I make no objections; but I must consult with some one."

"And with whom, pray, do you wish to consult?"

"Bless me! the mayor, the notary of Villeneuve-Saint-Georges."

"That is foolish. If you wish to consult any one, let it be a man who knows me; my friend M. Mellinot, if you wish: but don't mix up mayors and notaries in the matter, or you must understand that I have said nothing."

"Exactly, sir, exactly. M. Mellinot is a worthy man, and I have confidence in him; but" —

"There is no 'but:' I give you five days to reflect and consult, as it concerns you. This is the 11th of June; on the 16th I shall expect you at Hay before dinner, with little Jean, whom you will bring in the wagon. I shall pay for the journey and your time. If you are not at Hay before six o'clock, well, all will be ended. Now, my wor thy fellow, good-day."

Saying which, M. Majorin moved towards the door.

"Ah, after all!" said he, turning back, "it is understood that if you leave the boy with me, I will bring him or send him to you twice a month to see his mother, brothers, and sisters: he shall pass the day with you, but must return to Hay in the evening. Good-day."

During this dialogue Euphrasie, the boy's mother, stood with her arms hanging down, and did not utter a word, though big tears rolled down her cheeks.

As for Jean, he crept to the door, and looking fixedly at M. Majorin while he mounted his horse said, —

"Sir, I wish very much to go with you."

"Make yourself easy, my boy; and if you wish to come with me don't say a word. Do you understand? not a word."

As soon as M. Majorin left, Euphrasie burst into sobs.

As we have said, Loupeau was an impatient man, and M. Majorin's propositions left him somewhat perplexed; but his wife's groans and sobs, far from increasing his doubt, seemed, on the contrary, to provoke him to a decision.

"Well, mother," he said to his wife, "what makes you bray so? Does any one wish to eat your little one? If this gentleman desires to assure his future, is it any thing to grieve about? It is nothing at all: he is not a were-wolf. If it is his notion, since he has no children, to educate one for a profession, it might as well be our son as the son of any one else. I shall go to Paris to-morrow to see M. Mellinot; and, if he tells me that his friend is a worthy man, I will take our little boy to him on the appointed day. It wouldn't do any harm to let him go; for he will keep him only six months. He will be no cost to us during that time, and will constantly be learning something."

Thereupon Loupeau went away to his work.

The next day when he informed M. Mellinot of M.

Majorin's proposition, the professor remained thoughtful a moment, and allowed the gardener to ramble on in endless sentences.

"In order to give you my opinion, friend Loupeau," said M. Mellinot finally, "I must write my friend, and receive an answer from him. If you do not hear from me, keep your little Jean at home. If I write to you, or if I can go to see you, it will be only to urge you to accede to M. Majorin's wish; of course, in either case you can act as you think best. I can only give you my advice, which you can follow or not."

As soon as Loupeau left, M. Mellinot wrote M. Majorin the following letter: —

Dear Friend, — Loupeau, who has just left, has told me of your offer in regard to his son, little Jean. He asks my advice, but in order to give it I must know your intentions about the child: therefore, if you do not think I take a liberty, let me ask you to tell me in a few words what you intend to do with him; or, what is better, come and dine with us to-morrow, and we will talk it over.

Yours truly,

J. Mellinot.

The next day M. Mellinot received the following answer: —

Hay, June 13, 18—.

I am detained here, my dear friend, and cannot accept your cordial invitation. Perhaps you think that this is but a fancy of mine in regard to little Jean, but it is not. I intend to make a useful experiment. His wide-awake face and answers, and — since I must tell

you every thing — his sketch of the cat, of whose authenticity you expressed some doubts, but which in my eyes was genuine, have put an idea into my head, which, in your official wisdom, you will probably think foolish, although I believe it excellent. The little fellow is evidently endowed with uncommon powers of observation, and he remembers what he sees. Well, apart from regular instruction, which I do not wish to decry since you are one of its advocates, I wish to see what can be done with a youthful mind by putting it in the way to observe, and to turn its observations to good account, at every moment. Even if I make him a good workman only, I shall not compromise his future. Then, I am becoming sad: I have no one near me, and this little fair-haired child will perhaps fill a void in the heart of your old friend; who knows?

Your friend,

MAJORIN.

After receiving this answer, M. Mellinot sent word to Loupeau that he would visit him at Boissy Saint-Léger, on the 15th, and that he thought his friend's offer one that should be accepted.

Thus the matter was decided. M. and Mme. Mellinot, provided with a new suit for Jean, reached Loupeau's house near noon, at dinner-time, in order to find the family united. Euphrasie still wept, but forced back her tears, seeing that they irritated her husband. Jean, his face flushed with happiness, tried on the new suit; and then it was agreed that early the next morning Loupeau should take him to the factory at Hay. That night neither father, mother, nor Jean slept a wink.

CHAPTER III.

TREATS OF SEVERAL NOTABLE DISCOVERIES MADE BY JEAN.

AS a matter of course, M. Majorin, being occupied in the factory at Hay the greater part of the day, could not look after Jean: therefore he placed him at a country school; but in the evening when it was pleasant, both went on a ramble through the fields, and when it rained they remained at home. They also visited the studios, and M. Majorin always had something interesting to show his *protégé*. He made him reason, and ask questions, and unceasingly employed his mind and eyes by teaching him to form a habit of accounting for every thing.

In a week they were the best friends in the world; and Mme. Orphise, an old nurse in the service of M. Majorin, took care of the child, put him to bed, and woke him in the morning, gave him his soup, and carefully filled his lunch-basket before he went to school, and

would have really spoiled him if her master had not prevented it.

"Now that you are acquainted with the house and those who live in it," said M. Majorin one evening, "the dogs, the cats, and the chickens, the garden, and a part of the neighborhood, we must begin our studies with method. Do you know what method is?"

"No, good friend." (It was thus that M. Majorin wished to be addressed by Jean.)

"Well, method, little one, is to put every thing in its right place, and to do every thing at the right time. When Mme. Orphise makes your soup, how does she begin?"

"She puts it on the fire to warm, and then — she puts bread in it."

"And then you eat it. Is that all?"

"Dear me! no: there are carrots and cabbages in it."

"And where does this soup come from? Does she go to the spring for it?"

"Oh, no! M'ame Orphise makes it beforehand."

"Ah! of what?"

"Beef and vegetables."

"And salt?"

"Yes, and salt."

"Then, to make your soup, it was necessary to think beforehand, as you say, of every preparation for it: namely, the purchase of a piece of meat, money in the pocket

to pay for it, and a basket on one's arm to put it in; to go in the garden to dig carrots, and cut a cabbage; to go to the spring to fetch water in a very clean jar, and then to boil it; next to have plenty of coal ready; then to pick over the vegetables, and, while the water is still cold, to put meat and carrots in it; to watch lest the water boil over, to skim the scum which rises to the surface, to salt the soup, and, of course, to have enough salt at hand. Then, when the meat has boiled enough to change the pure water into soup, to pour it into a soup-tureen, in which one has first put pieces of bread, and then to put aside part of this soup for the next morning's meal. Method, then, consists in performing each of these operations at the proper time. Without method, you have no soup, my dear boy. Well, whatever one does in life, if he wishes it to succeed, must be done with method. Do you understand?"

"Yes, sir."

"Well, repeat to me how soup is made."

Jean made the attempt; but he forgot first one thing, then another, so M. Majorin stopped him, and both friends laughed heartily.

When the various operations, through which a soup must pass to be eatable, were exactly related in their order by Jean, M. Majorin continued thus: —

"When you see any thing, — a piece of furniture, tool, or house, — you must ask how it is made, with what, and

why, and try to guess it yourself, or, if you cannot, ask those who know. When you see an animal, big or little, a horse or a sheep, or an insect or a bird, you must ask what they do in order to walk, to defend themselves, to get sustenance, and to fly. When you see a plant, you must ask how it comes up from the earth, how it pushes forth shoots; and watch closely, and see how the leaves, flowers, and fruit are attached.

"But, above all, that you may proceed methodically, you must know something of geometry. Do you learn geometrical drawing at school?"

"Yes, sir."

"It is what you call rounds and squares."

"Yes, sir: and also strokes and triangles and lines."

"What do you learn from all this?"

"I don't know."

"You do not know of what use they are to you. Do they not tell you?"

"No, sir: they tell me nothing."

"But what do you think of when you draw the figures (for such they are called) on your slate or paper?"

"I think that they are squares or rounds."

"Circles you mean."

"Yes, circles."

"And do not these figures recall any thing to your mind?"

"Yes, sir: round things and square things."

"Well, is the top of this table round, or square?"

"It is square."

"No, it is not square; since a square has four equal sides, and the top of this table, as you see, has two sides visibly longer than the other two. It is a rectangle, that is, a figure having four right angles. Do you know what a right angle is?"

"Yes: it is an angle like the corner of the table."

"And how do you know the corner is a right angle?"

"I see it perfectly."

"Are you sure? Go bring the little iron square that hangs on the nail."

And M. Majorin, placing this square to the angle of the table, showed Jean that one of the two sides of the shelf did not quite touch the arm of the square in its entire length.

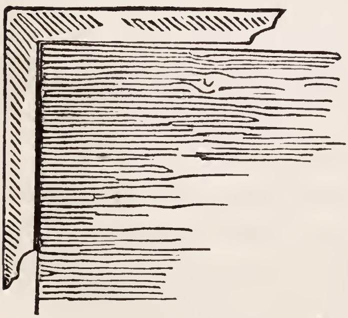


FIG. 2.—THE SQUARE.

"See," continued his teacher, "this square is a right angle, I am certain, because I have measured it. Well, one of the sides of the shelf projects beyond one of the branches of this square, while the other is of exactly the same length; therefore this angle of the table is not a right angle, but an acute,—a very small one, but still an acute,—and you are mistaken.

"I will show you now how one can be sure that a square gives a right angle.

"Pass me that piece of chalk."

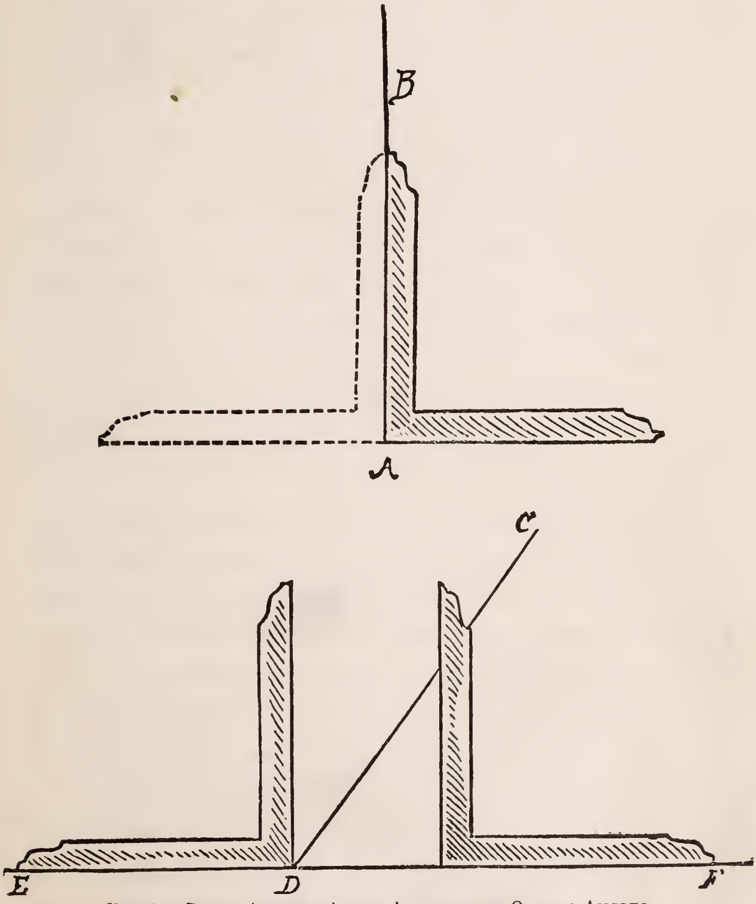


FIG. 3.—RIGHT ANGLES, ACUTE ANGLES, AND OBTUSE ANGLES.

M. Majorin then drew a straight line on the table, and, with the aid of his square, another line joining the first; then, turning the square round, its two branches exactly touched the two lines in both directions. (See Fig. 3.)

Again, drawing an oblique line meeting a straight, he showed Jean that if one of the branches touched the line at the base, the other projected beyond the oblique on one side, or cut it if one turned the instrument around.

The line A B is called perpendicular, and its property is to give at the right and left two right angles with the straight line on which it falls; while the name of obtuse is given to the angle C D E, that of acute to C D F, and the point D is called the vertex of these two angles.

The perpendicular lowered a degree on a straight line gives, then, two angles, which are right angles, and equal to each other.

"Now, we will draw a circle with a compass thus (Fig. 4); then we will pass a straight line through the centre of it at O; and this line is the diameter of the circle. From this centre, let us raise a perpendicular line on this diameter above, the same as beneath it, and we have four right angles. Let us divide each of the four quarters of the circle into ninety parts; and these ninety parts are degrees, which give 180 degrees for the half of the circumference of the circle, and 360 degrees for the whole. If from the centre we take a line passing through one of these divisions of the circle, we shall have an angle which

will be named from the number of the degrees. Thus the figures 45 divide into two parts the segment of 90 degrees, which makes a quarter of the circle. If we pass a

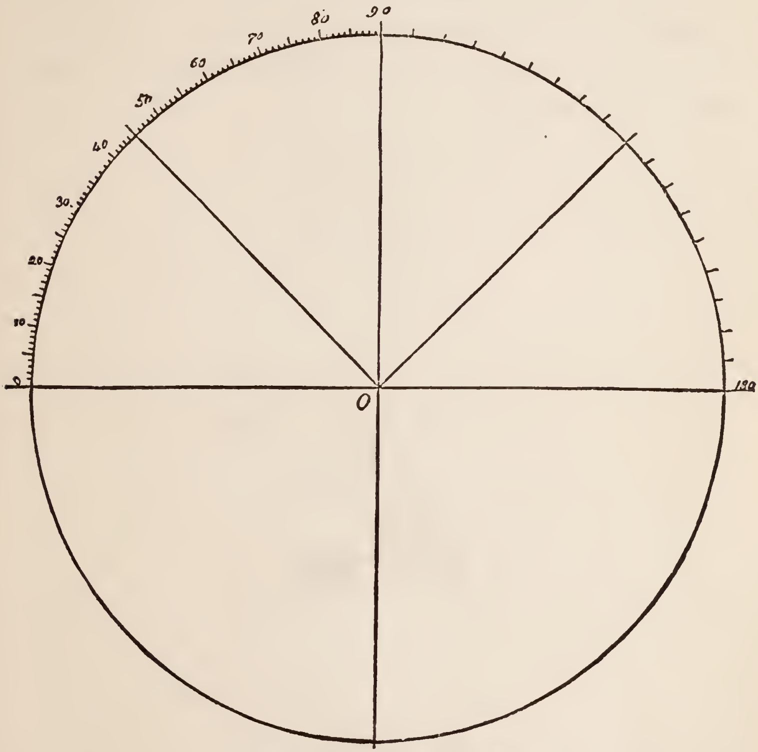


Fig. 4. — Graduated Circle.

line from the centre through this degree of 45, we shall have, with the two diameters cutting each other at a right angle, two angles which we shall designate by these fig-

ures. These two angles will be angles of 45 degrees. When one gets this well into his head, and sees any angle whatsoever, his practised eye will enable him to say, 'This is an angle of 30 or 60 degrees.' But this is enough for this evening. Reflect on what I have been telling you; and to-morrow we will try to apply our first lesson in geometry."

CHAPTER IV.

JEAN LEARNS THAT GEOMETRY IS APPLIED TO SEVERAL THINGS.

THE next day M. Majorin, while walking after dinner in the garden with Jean, said to him, —

"Gather that ivy-leaf, and tell me what you see in it."

Jean hesitated before answering.

"Do you not observe that it is composed of a support which is called the petiole, which is attached to the stem, and of other things besides: of a membrane, which is the skeleton of this vegetable appendage, and of a green tissue called the blade?"

"Yes, sir."

"And do not these ribs of the leaf tell you any thing?"

"Yes. There are five of them; that in the middle is the longest."

"And the others?"

"The others are smaller."

"Well, keep this leaf, and do not spoil it; and we will presently see what it will tell us."

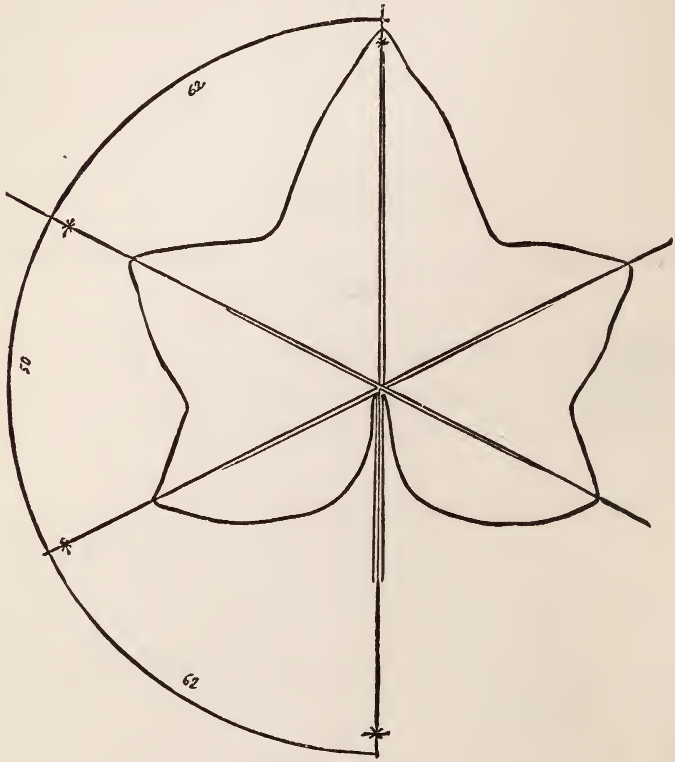


Fig. 5.—Ivy-Leaf.

When M. Majorin entered the house, he took a graduated circle, and, placing the petiole where it joins the blade on the centre of the circle (Fig. 5), he showed Jean

that the ribs of this leaf were so disposed, that they gave with the petiole and the rib of the axis two angles of 62 degrees and one angle of 56 degrees, — total, 180 degrees; and the ribs of the other part of the blade gave the same angles, within a very small fraction; that the midrib was the longest, the lower ones shorter, and the lowest of all shorter still.

Jean began to find many properties in this leaf.

"Are all the leaves of the ivy made in this way?" he asked.

"Not entirely: the midrib is more or less long, and consequently the leaf is more or less sharp or thick; but there are always these five ribs, leaving between them angles which differ but little from those we have just observed.

"But yet the ivy-leaf, like all the vegetable and animal appendages, independent of the varieties which each individual presents (for there are not two leaves of the same plant that are identical), is subject to the irregularities caused by a sickly state or an excess of nourishment.

"Privation and abuse are the great causes of degeneracy or corruption. By the side of the modest ivy-plant, from which you have gathered this well-formed leaf, there is another which grows to excess, perhaps because it has found a very rich soil. This other plant sends out wild shoots on every side: it is too ambitious, and I am obliged from time to time to check its advance by the aid of shears.

"Well, here are two of the leaves of this luxuriant plant, which I have gathered on this side. See, they vary from the regular plan, and are deformities; and, if you will examine the plant, you will find a number of leaves, which, in their haste to develop, have not been governed by the common principle (Fig. 6). Prosperity spoils them, and changes their form. This is to teach you, that in nature you must select everywhere and constantly; and when you wish to reproduce the form of a crystal, plant, or animal, adhere to the rule which is imposed on each, and avoid what is unnatural. But this belongs to æsthetics. Do you know what æsthetics are?"

Fig. 6.—Deformities.

"Oh, no!"

"You will later, I hope, and without suspecting it.

"You understand, then, that geometry has something to do with leaves. Here is another example," continued M. Majorin, opening an album in which were fastened leaves of plants: "this leaf of a vine (Fig. 7) is contained

in a regular pentagon. A regular pentagon is a figure composed of five equal sides and five equal angles. You will observe, that, although the two large lateral ribs are curved, they follow a symmetrical direction, and end in

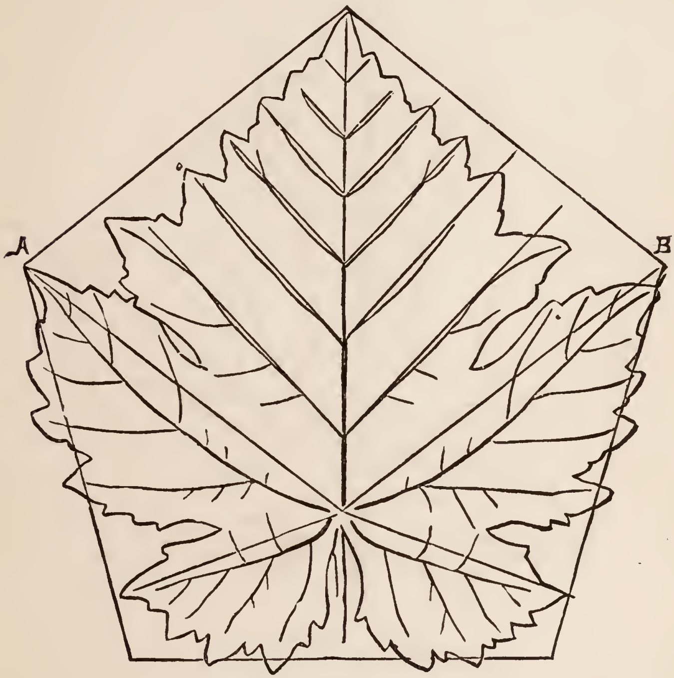


FIG. 7.—LEAF OF A VINE.

the angles A B of the pentagon. Does this mean that all leaves of vines are exactly of this form?

"No; but all those in favorable conditions present the same character, and possess their five principal ribs, that

of the straight axis being longer than the other four. And this leaf of a fig-tree (Fig. 8) also forms, does it not, an irregular but symmetrical pentagon, the extremities of

Fig. 8.—Fig-Leaf.

the ribs exactly meeting the angles of the geometrical figure?

"And does not this leaf of the convolvulus (Fig. 9) form a triangle? And so on with all the leaves of the vegetable kingdom which describe geometrical figures.

"But when we examine minerals we find it quite otherwise. You will see that in their formation they assume forms borrowed from what are called solids; that is, from bodies produced by geometrical figures.

"Geometry is part of every thing, and is met everywhere, and is the great mistress of nature: therefore one must learn it, if one wishes to observe and comprehend the works of creation.

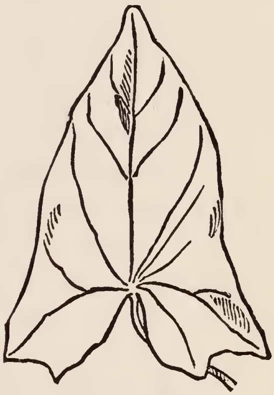


FIG. 9.—LEAF OF THE CONVOLVULUS.

"I have said enough to make you understand that you must look upon things in this world with the thought that every thing is subject to a fixed law, and that the skill of the observer consists in discovering these laws. There is no work of nature without design, but very often this design is concealed on account of our imperfect intelligence.

"Have you ever seen a honeycomb?"

"Yes, sir."

"You know that it is composed of cells, or little tubes of wax, placed side by side, which assume the hexagonal form; that is to say, a polygon with six sides, like the clay tiles in the hall.

"Do you know why these little tubes, or prisms (that is the name given those which are not circular, but which

have straight sides, the tubes cut in round form being called cylinders), — why these prisms have a hexagonal form? Can you tell?"

"No, sir."

"Do you think they could take another form, that of a square for example?"

"I do not know."

"Well, these tubes, or prisms, are, it is said, on a hexagonal base because they could not be otherwise: we will make an experiment to show you."

Whereupon M. Majorin, taking a rubber tube whose walls were very thin, began to cut it in small fragments about a centimetre long. When he had about twenty of them, he took a strip of pasteboard of the same length, and arranging these pieces of tube regularly, one by the side of the other (Fig. 10), he surrounded them with the sheet of pasteboard, which he gently and regularly tightened, thus gradually pressing on the tubes; and to Jean's great amazement all these tubes, cylindrical as they were, assumed the form of hexagonal prisms. (Fig. 11.)

Fig. 10. — Union of the Cylinders.

"You see," said M. Majorin, after fastening the pasteboard strip with a little sealing-wax, "that all the spaces which were originally between the tubes have disappeared. These compressed tubes have filled them, and their circular walls have become hexagonal. Well, each bee perhaps undertakes to make a tube; but as it works by the side of its neighbors who are as strong as itself, it is necessary to make mutual concessions, and to respect the spot its neighbors occupy, without leaving spaces between the cells, since the walls are also division-walls; hence each of them endures the pressure of its neighbor, and is forced to adopt the prismatic hexagonal form. And thus bees obey the laws of geometry without suspecting it. The intelligence of man permits him not only to prove this fact, but to discover the cause or law. And thus it is with every thing, and therefore his intelligence must be constantly exercised, and he must observe every thing; that is to say, look and seek the reason of every phenomenon, for there is neither chance nor effect without cause."

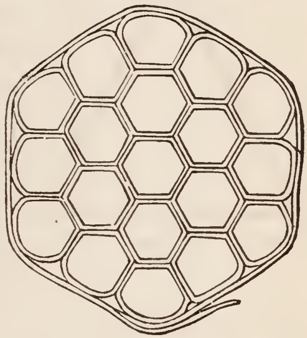


FIG. 11.—UNION OF HEXAGONS.

After saying this, M. Majorin drew an equilateral triangle (Fig. 12), and showed Jean, by the means of the compass, how this triangle is composed of three equal sides, and,

by means of the graduated circle, how the three angles are equal to each other, each of them measuring 60 degrees: consequently these three triangles give together 180 degrees, equivalent to two right angles, which are 90 degrees. Then, having cut six of these equal triangles out of a sheet of paper, he united them (Fig. 13), and showed Jean how these six triangles composed a regular hexagon; how, each of the angles of this hexagon being 120 degrees, the six together give 720 degrees, or eight times 90 degrees; that is to say, the value of eight right angles; and how geometry and arithmetic are thus sisters, and give each other mutual support, in contributing to the knowledge of the properties of figures and bodies.

Fig. 12. — Equilateral Triangle.

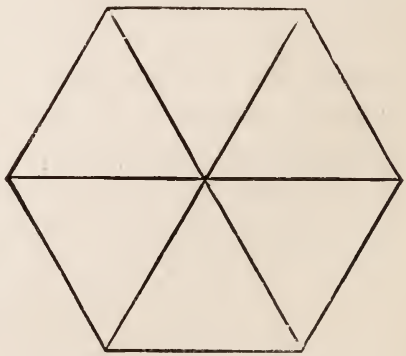


Fig. 13. — Regular Hexagon.

All this greatly astonished Jean, but his mind was rather confused. Although M. Majorin perceived it, he still continued; and, taking a playing-card, drew on it six equal squares placed opposite

each other in the form of a cross (Fig. 14). Then he folded each square, and bending them, as in Fig. 15, made a cube (Fig. 16).

"This," he continued, "is what is called a solid; and this solid is a cube formed, as you have seen, of six equal squares. Geometrical figures drawn on a piece of flat paper may then serve to form bodies and solids; and, as the general name of polygon is given to these figures, the general name of polyhedron is given to these solids, which means for the former a figure with several sides, and for the latter a solid with several faces. The most simple polyhedron, that is to say, the one which has the smallest number of faces, is the pyramid with a triangular base."

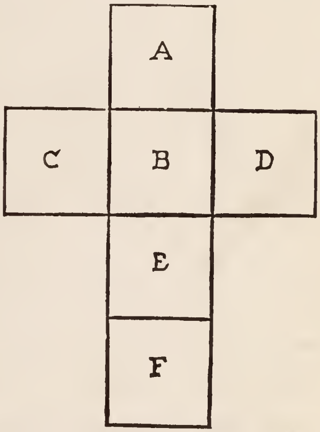


Fig. 14.—Development of the Cube.

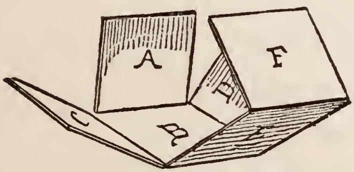


Fig. 15.—Formation of the Cube.

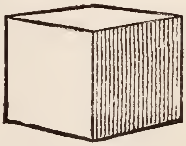


Fig. 16.—Cube.

And drawing on another playing-card an equilateral

triangle, on each of whose sides he raised three other equilateral triangles, M. Majorin folded these three triangles by uniting their three vertices (Fig. 17), which formed a pyramid. He continued thus: —

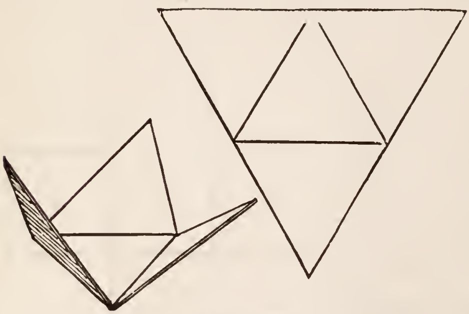


FIG. 17. — FORMATION OF THE REGULAR TETRAHEDRON.

"The pyramid with a triangular base has four faces, and bears the name of tetrahedron. The cube has six faces, as you have just seen. But do you think that one can form tetrahedrons only with four equilateral triangles? No, certainly not. By drawing lines from a triangle with any base A B C (Fig. 18) to any point D, one obtains three triangles of any kind, A B D, B C D, A C D, and a pyramid more or less high in relation to its base, and irregular, inclined, &c. Also the polyhedron with six faces need not be a cube; but can be, for example, a rhomboid, that is, a solid composed of six rhombs, or lozenges."

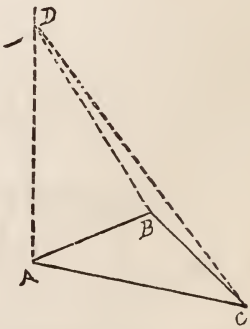


FIG. 18. — IRREGULAR TETRAHEDRON.

And, proceeding as before, M. Majorin drew on a card

six lozenges placed at equal distances, folded the figure at the lines of meeting, and made a rhomboid (Fig. 19); after which, he ranged all these figures in a drawer, rose, and said to Jean, —

"Now, before going to bed, let us take a turn in the garden. The moon is superb."

After walking a few steps in the gravelled paths, Jean said, —

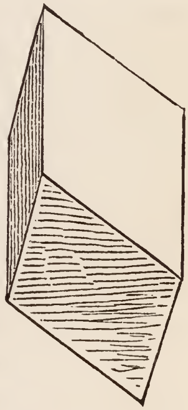


Fig. 19. — Rhomboid.

"Good friend, why is the moon round for so short a time?"

"Do you think it ceases to be round, or, to speak more correctly, spherical, for a certain time; that it loses a part of its substance, first on one side, then on the other? It appears to you to have the form of a crescent, then of a half-sphere, because it is lighted more or less obliquely by the sun; the side in the shade disappears, and is confounded with the atmosphere of the sky, unless the weather is clear enough to show this side lighted by the reflection of the earth, — by the *earth-light* as the inhabitants of the moon might say, if this satellite had any inhabitants."

"Are there not inhabitants in the moon?"

"It is not probable, since it has neither atmosphere nor water."

"Then, what is there in it?"

"I do not know; but on its surface there are a large number of mountains and elevations, which I will show you some evening with the telescope."

"Can one see trees in it?"

"Strong as the glasses are, they cannot bring the image of the moon near enough for one to distinguish trees; but the want of atmosphere and moisture, which prevents animals from living in it, also prevents all vegetation, which cannot exist anywhere without air or water."

"They told us at school that the earth turned round, but that the moon did not turn: is it true?"

"The earth turns on itself, on an axis, like a top, while it describes an orbit around the sun which it takes a year to complete; while the moon turns entirely around us as we turn around the sun, but it does not revolve on an axis like the earth, and it always presents the same face to us. If you fasten a ball to the end of a string, and twirl it around quickly, as you hold the string firmly in your hand with a strong tension, you will observe that the same side of the ball will always be towards your hand. Suppose your hand to be the earth, the ball will be the moon; the string, what is called the attraction; and the power which gives tension to the string will be the centrifugal force. If the string breaks, your ball will fly away: in the same way, if the force of attraction should cease to act on the moon, it would very quickly move away — God knows where. But all this is regulated by

fixed laws, controlling the course of the earth as well as the cell-making of the bee of which we spoke just now. And that is why it is necessary to observe, and also to try to discover and remember, these laws: thus, if one never becomes weary, one may be useful to others, foresee danger, and protect one's self; give wise advise to those who ask it, and become a well-informed man, ready for any emergency.

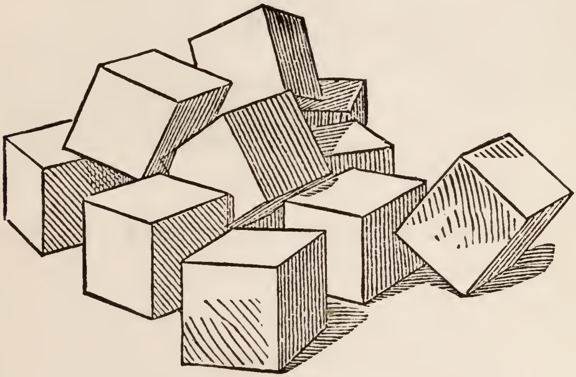


FIG. 20.—PILE OF CUBES.

"To-morrow is Sunday; and, as you will not go to school, you must make several of those little cubes and rhomboids with cards (Figs. 20, 21); then we will place them on the table and copy them. You must also seek leaves in the garden, and classify them in a manner to observe their varieties, and wherein they resemble each other, and in what they differ; and draw on the paper,

as well as you can, at least their principal ribs. But here is Mme. Orphise calling you, for she thinks you are sitting up late. Go to bed now: good-night."

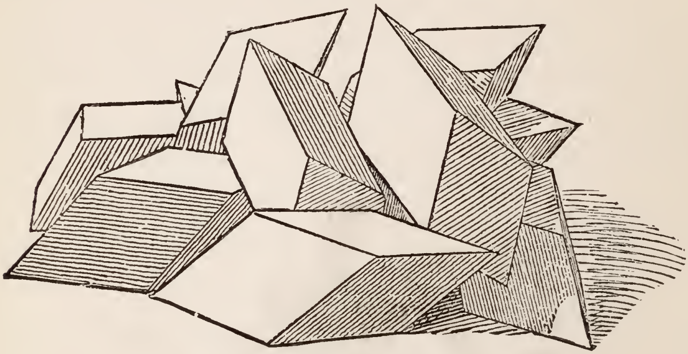


FIG. 21. — PILE OF RHOMBOIDS.

Jean dreamed of cubes, pyramids, and geometrical figures outlined on the surface of the moon held by M. Majorin on the table. Then the moon became an ivy-leaf, which he cut up while looking at it through a glass. Then M. Majorin said, "This is of no use, for there is no atmosphere."

CHAPTER V.

OTHER DISCOVERIES BY JEAN CONCERNING LIGHT AND DESCRIPTIVE GEOMETRY.

THE next day, after Jean had fashioned a large number of cubes and rhomboids with playing-cards, by fastening the edges by means of thin strips of delicate paper and gum, the two friends went to walk in the direction of Sceaux.

"You see," said M. Majorin while climbing a path which ascends from the mill at Hay to the park at Sceaux, "that, the higher one goes, the more land he discovers around him. A while ago, we did not see Cachan, and now we see its gardens.

"The horizon, that is to say the line that separates the earth from the sky, rises as we ascend, and seems to be always on a level with our eye. I will explain to you why it is so when we are home again.

"Look at this boundary-wall on this side: it is still lighted by the sun, whose rays skim its surface, and

linger where it is rough. The nail fastened there casts an endless shadow. It is because the sun is on a line with the wall; in a few moments it will have passed beyond, and the surface now lighted will be in shadow. Look: it is so already, and the surface which was so brilliant with light takes a bluish-gray tone, because the wall reflects the brilliancy of the sky, which to-day is pure. The stronger the light of the sun, the clearer will be the atmosphere and the brighter the reflections.

"When you travel in the East, you will observe that the difference between a surface lighted by the sun, and that which does not receive its direct light, is often hardly apparent, reflections having such brilliancy in countries where the atmosphere is dry and pure, and where the sun is very high.

"If, on the contrary, you light an object by means of a good lamp, you will observe that if the part directly exposed is brilliant, that which is opposite is very dark, and receives only an almost imperceptible light from reflection."

Jean listened attentively, but much that M. Majorin said was not understood by him. Nevertheless he did not ask very many questions of his friend, who had said to him, —

"When I try to teach you any thing, and you do not perfectly understand, do not at the time ask me to give you an explanation, but try to remember what I tell you, and try to find it out yourself; and only when you cannot succeed, is it well to ask me to enlighten you."

Jean did this as a matter of course; and, when he did not fully grasp M. Majorin's discourse, he sought to comprehend it unaided, without asking a question till he had exhausted every resource which his small powers of reasoning could furnish. Besides, M. Majorin, who suspected that indolence of mind which is as natural to children as to grown persons, would boldly ask Jean in two or three hours, or the day after one of these familiar talks on a particular subject, to explain one of the points involved. If Jean gave the explanation, he was satisfied; but if he hesitated, he would say, —

"Did you not understand? Have you reflected? Not enough, you say? But you must try. I will repeat to you what I have already said, and you must try to comprehend, and tell me what you have learned."

The sun was setting, and its slanting rays gilded every surface on which they fell. Jean ventured this question:

"Why, good friend, are objects yellow when lighted by the sun in the evening?"

"Have you noticed that?"

"Yes, sir."

"And have you not noticed the same thing in the morning?"

"Yes, indeed, sir. When I used to work with father, and he took me out very early in the morning, I saw that the sun was yellow, though not so much so as in the evening."

"And how do you explain it?"

"Perhaps it is because one is tired in the evening, and the sun then appears yellower."

"No, that is not the reason: whether one is tired or not, the light of the sun, without exception, appears yellower or of stronger color in the evening than in the morning, because the atmosphere is more charged with moisture at that time than in the morning, the sun during the day having caused the evaporation of a large quantity of the water on the ground. You know that when the sun comes out after a rain, the wet ground, whether paved or gravelled, immediately becomes dry. Now, where does that water go? Into the air. The sun has pumped it up, but cannot absorb it on account of the distance; and, as the water cannot leave the earth, it remains in the atmosphere in a state of transparent vapor. When the sun approaches the horizon, and is about to set as it is called, its rays cross a stratum of air which is denser than that at the meridian when it is noon, and consequently much more of this volatilized water fills it. There are innumerable drops of water which thus color these rays yellow and sometimes even red."

And M. Majorin, taking a pencil and his memorandum-book, drew the following diagram (fig. 22): —

"Suppose," he continued, "that a section of the earth is here at T, with its stratum of air or atmosphere V, and a city at A: when the sun is above it at S, its rays cross

but one stratum of air, whose density is *a b;* but when the earth has been moving for some hours, and the city is at A′, the sun's rays cross a stratum of air *c d*, which is much denser, and, consequently, contains more water in suspension; and thus these rays, crossing a much larger

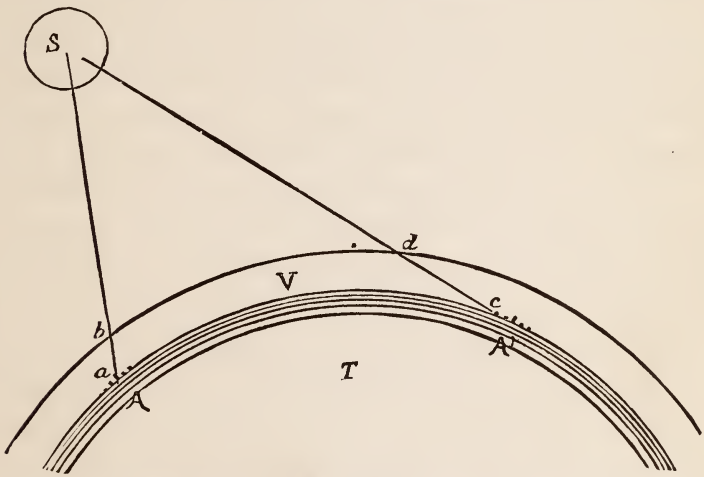


FIG. 22.—WHY THE LIGHT OF THE SUN IS COLORED RED OR YELLOW AT EVENING.

number of drops of water, are less burning, brilliant, and clear than they were at noon, and they assume the color of yellow, orange, or red, as the atmosphere is more or less charged with moisture. In the morning, a part of this moisture returns to the ground, and is what is called condensed. There is less in suspension in the air; and the sun, appearing at the horizon, does not pierce so many drops; that is why the rays of the sun when it rises are,

as you have correctly observed, less colored than at sunset. And this makes it clear to you again, that, though it is well to observe with exactness, you must persistently seek the cause of the fact or of the phenomenon observed."

While M. Majorin thus discoursed, the sun, hidden below the horizon, no longer projected a single colored ray on the tree-tops; but a long line of clouds remained brilliant as melted gold near their lower edges, while they were dark lilac near the upper. And, calling Jean's attention to this, M. Majorin continued as follows: —

"Can you explain why these clouds, which in the daytime are lighted from above by the sun which seems to be over them, are at this hour lighted from beneath as if by a fire?"

"It is because the sun has gone down."

"The sun is neither down nor up; and its distance from the earth varies very little; or, rather, it is we who turn round it while always maintaining between it and ourselves nearly the same distance throughout the year, or during the entire revolution. There is neither up nor down in the universe; there are only distances and relative positions: and, that you may thoroughly understand how it is that clouds in the evening or morning are lighted from beneath, I give you another illustration which will explain the phenomenon. (Fig. 23.)

"When the sun is at S to you who are at A, on the ground, T, the cloud N receives the light on its upper

side; but when the earth has turned, and you are at A, you can no longer see the sun, because the whole section, A′ B, of the earth hides it from you, and yet it still lights the cloud N′ from beneath, and you can enjoy the highly-colored light, because it crosses a thick stratum of atmosphere, N′ O. That is why the brightness of those clouds, lighted from beneath, has the color of fire. In this

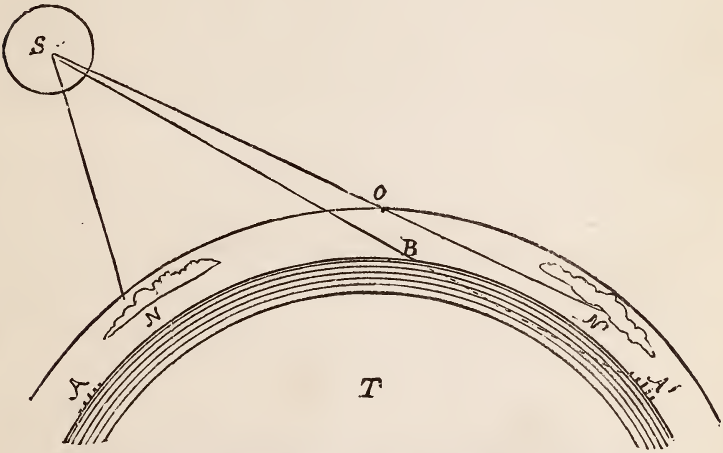


FIG. 23.—HOW, AT SUNSET, THE CLOUDS ARE LIGHTED FROM BENEATH.

illustration I show you the earth large and the sun small, which is the reverse of reality, because the sun is to the earth nearly what a pumpkin is to a grain of millet: it is also so far away that if you were to take the cars, supposing there were a railroad leading to it, and an express-train, you would live to be ninety before you could make a quarter of the journey."

After supper, Jean, whose curiosity had been roused by all that M. Majorin explained to him in the afternoon, returned to the subject of the horizon, and made this remark: —

"You told me, good friend, that the horizon is always on a level with the eye; but how is it when one is in a balloon?"

"Just the same: the horizon rises with you, or seems to, for all that we see are appearances. Thus apparently the sun turns round the earth, and men long thought it did so — they saw it! and yet it is the earth that moves

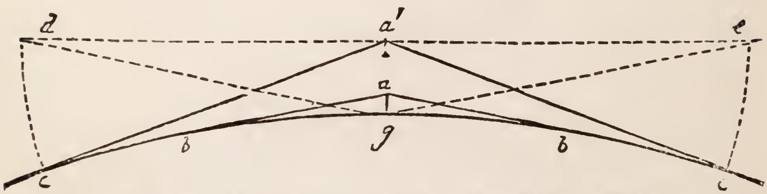


FIG. 24. — THE HORIZON, ALWAYS ON A LEVEL WITH THE EYE.

round the sun. When one sees thin clouds, driven by the wind, pass rapidly between himself and the moon, he would positively assert that it is the moon which moves. When one's eye takes in an immense plain, the latter appears flat; and yet it is convex, since it is a portion of a sphere or a ball. Thus it is with the horizon, which appears to rise with us: of course it does not move, but as we ascend we discover a wider extent of it, and it seems to spread out before us like a canvas.

"But, according to my promise, I will make this clear to you. Let Fig. 24 represent a section of the earth: if you stand at *a*, you will see the whole surface of the earth (*a b b*); but if you ascend, even in a balloon, and stand at *a′*, then you will see the whole portion of the terrestrial *calotte* (*a′ c c*), which is much more extended than was that at *a b b*. You will find yourself at the top of a cone. Do you know what a cone is?"

"Yes, sir: it is like a paper horn."

"This is a cone." (Fig. 25.) "You will find yourself at the top of one whose base is the terrestrial *calotte* which you see. This cone is much more flattened than a paper horn or a package of loaf-sugar; but it is none the less a cone, the greater or lesser distance from the vertex to the base making no difference. But high as you may ascend, even in a balloon, the distance that you place between yourself and the earth is so slight, compared to the circumference of our globe, that you do not perceive that your visual ray, in following the line of the horizon, describes a conical surface. You think that it follows a straight line (*d e*), and therefore this part of the earth that you see seems to rise, and form the reversed cone (*g e d*); as, when one is in the car of a balloon, it seems as if one were suspended in the middle of an immense

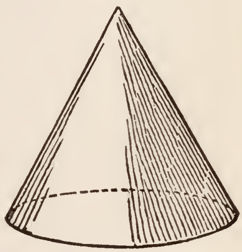


Fig. 25. — Cone.

cup whose edges rise to the height of the balloon (Fig. 26). Without a balloon, one may ascend to the top of a very high and isolated mountain, like Etna for example, and experience the same impression.

"Sicily, the sea, the straits of Messina, and the Italian coasts seem to rise gradually to the limit of the horizon, and to represent an immense geographical map. We do not have a conception of the convexity, that is to say, of

FIG. 26.—OPTICAL ILLUSION OF THE SPECTATOR IN A BALLOON.

the arching of the visible portion of the earth, but of something quite the reverse. This visible portion of the earth would seem rather to have the form of a basin, in the centre of which would rise the mountain on the top of which one stands. It is by those illusions of the sight that men were long deceived concerning the nature and form of our globe, its proper movement, and its relation to the other planets which gravitate in space. And it has required long observation to correct the errors into which our sight has fallen.

"You must have found that the farther you move from an object, the smaller it looks to your eyes. A poplar-tree, which seems extremely tall if you are near its foot, will seem to be no higher than a pin if you look at it

from a great distance. And through the window-glass, which is hardly forty centimetres broad to sixty in height, you see, as in a frame, the yard and factory, the buildings in the background, and the tall chimney, and yet you are not unaware that all these places with their appurtenances are much larger than the glass; yet they are contained in its sashes. That is the illusion produced by perspective; but now that you know — if, indeed, you have clearly understood me — why and how the horizon is always on a level with the eye, you will without very great difficulty comprehend the elementary laws of what is called perspective. We will not talk of this until another day; for it is time for you to go to bed, and you must be tired."

And, indeed, Jean was so tired, that this night he did not dream, or he slept so well that he was not conscious of having dreamed.

We hardly need say, that every evening after school M. Majorin, in addition to the oral instruction that he gave Jean, made him, by means of the lamp, copy solids fashioned out of pasteboard, and observe how light fell on these objects, and explained to him the shadows cast from these solids on the table or on other bodies, using for the purpose a thread which he extended from the flame to the angles and edges of these solids, and thence to where it met the table and other bodies.

To show this, M. Majorin made a very small hole in a

lamp-shade as high as the flame, and through it passed a very fine wire secured by a small nail at the end: he needed only to move this thread along the edges or surface of the lighted bodies to show how the latter projected their shadows on surrounding objects (Fig. 27), and to

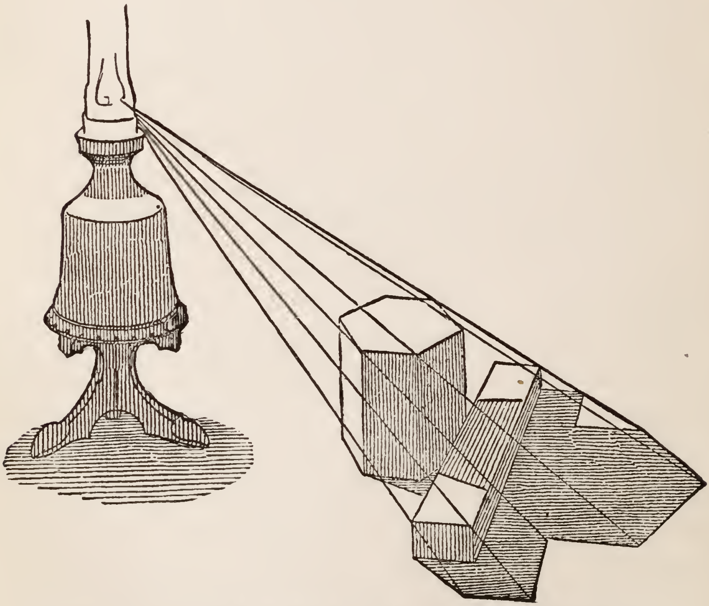


Fig. 27.—How Light falls from a Lamp, and determines Shadows.

have Jean learn, by turning round the bodies exposed to the light, how these shadows filled all the surfaces within the path followed by the extended wire.

Jean understood this very well: he began to draw

these solids and their shadows tolerably well, and M. Majorin said to him, —

" You understand, now, that the straight line is the shortest distance between two points, and what is called a line is not a stroke fine as it may be, since you see that in passing this thread along the edges and surfaces I define the light and shade, and that when the thread is not present this line of separation between the light and the shade does not the less exist, and thus this line in passing along the edges determines what are called planes, which here separate the light and shade.

" A plane is no more a tangible or visible object than is a line or a point. When you look at the head of a nail in the wall, you see no thread, and there are none, extending from your eye to the nail: there is, however, a straight line, for your eye, in aiming at the head of the nail, does not turn to either side; what is called the visual ray goes directly, and consequently by the shortest path, from your eye to this point. Now, if I draw a circle on this blackboard, and your eye follows the circumference of this circle, you pass the visual ray, or the line, which leaves your eye, through all the successive points of this circumference, and this visual ray, or this line, forms a cone, of which your eye is the vertex, and the circle the base. You have thus drawn in space a plane which is really a conical surface. You see this pencil. It represents a line; I throw it in the air, which it cuts, does it not? Suppose that, in

cutting it, it leaves the trace of its passage through space, this trace would be the visible plane which it determined in space ; but where its passage leaves no visible trace, it is none the less certain that it has cut the air, and that it has thus formed a plane. In the same way, if you throw a ball into the air, it will not leave a mark ; but it will none the less have described a perfectly defined curve. You have seen sky-rockets at the *fête* at Sceaux. Well, they left the trace of their passage for some seconds or fractions of seconds ; and this luminous track is a line, straight at first, but curving on reaching the point of explosion. If this pencil, which is a line, as the rocket is but a point, could mark its luminous course in space, you would not see a brilliant line, but a luminous ribbon more or less broad following the position of the pencil, a ribbon which would be the plane determined by this line.

"But if holding this pencil by the end, horizontally, for example, I make it follow a certain course, in taking care to keep it always at the same distance from the table, I determine a straight plane parallel to this table. If still holding the pencil by the end, but this time vertically, I place the end on the table, and follow a straight line, I determine another straight plane perpendicular to the table. Well, little Jean, descriptive geography and the science of perspective are embraced in the perfect comprehension of these planes which one traces at will in space, and which do not exist, but are seen by the eyes of intel-

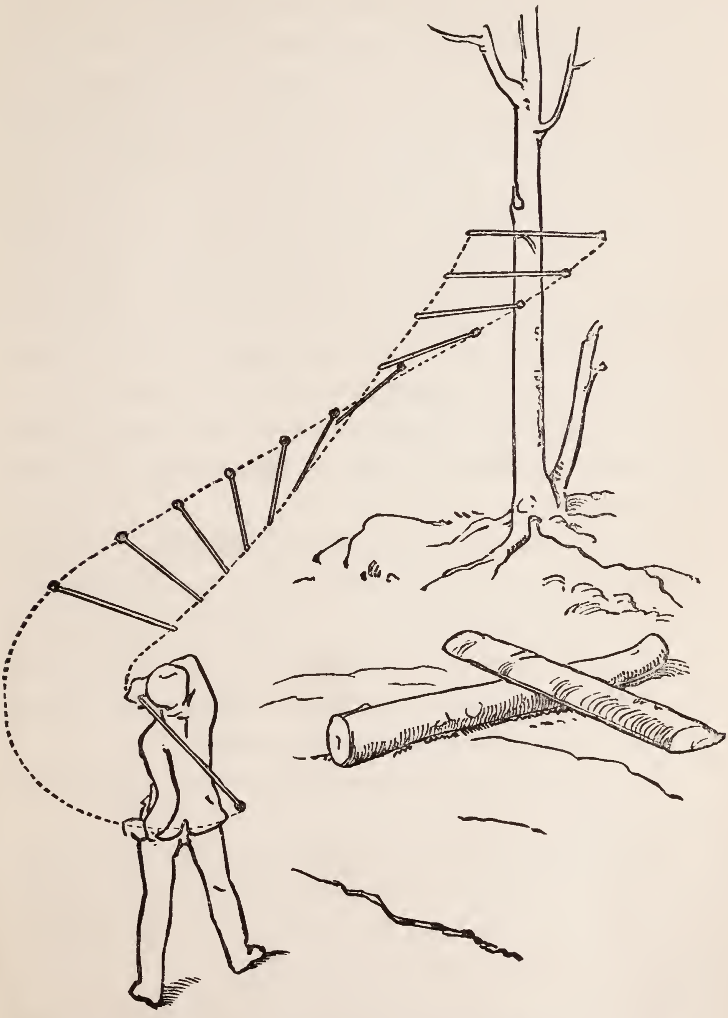


Fig. 28.—How a Stick, thrown into Space, determines a Plane.

ligence. I do not expect that you will know, this evening, what a plane is, and understand the use that can be made of it, but you will by and by. Meanwhile, in thought, try to admit what I have said, and to see these imaginary planes, which it is not very difficult to do, since, if you throw a stick at the trunk of a tree, you know perfectly well that your stick will trace a plane from a certain fixed point, which is your hand, to a body remote from that point, which is the trunk of a tree; you also know, that if you wish to strike the tree crosswise you must throw your stick horizontally."

And, according to habit, following oral demonstration by example, M. Majorin made the sketch (Fig. 28) on the blackboard.

"Here," he continued, "is the course made by your stick thus thrown; and the plane, which is more or less parallel to the ground which it traces in space, is limited on its edges by the length of the stick and by the position that it successively occupies in turning on itself, as it is forced to do by the motion your hand has given it.

"But this is a part of mechanics which we have not yet reached."

Nothing pleased Jean more than to see M. Majorin take the piece of chalk to draw on the blackboard, or a bit of pencil to accompany his explanations with sketches. He also would have liked to make them.

Meanwhile M. Majorin insisted on his copying these

outlines in a sketch-book as well as he could, and dictated to him the description which accompanied each diagram, putting the date at the bottom of the sheet in order to accustom his mind to work methodically. Jean at first had some difficulty in keeping his copy-book neat, and in placing the drawings in order. If, as happened three or four times, he skipped a sheet, or drew on the opposite side of the page, or had his copy-book upside down, M. Majorin did not become angry, but gave him a new copy-book with blank paper, saying, "You must begin again, my dear;" and Jean was obliged to do over again, following a strict method, all the sketches already drawn. In this M. Majorin found the double advantage of giving his pupil methodical habits in working and practising his hand, while making him review in his mind the preceding lessons.

CHAPTER VI.

CONTAINS A MEMORABLE CONVERSATION BETWEEN MM. MELLINOT AND MAJORIN, AND WHAT CAME OF IT.

JEAN had been at M. Majorin's three months, when the latter was apprised of a visit of the Mellinot family to Hay. The two foster-brothers, since M. Majorin's decision, had seen each other but twice, at the time of the Mellinots' visit to Boissy-Saint-Léger. Therefore both were to pass Sunday together as a holiday in the country. Dame Orphise profited by the opportunity to trespass on the frugal habits of the head of the manufactory, and prepare a breakfast worthy of the expected guests, followed by a dinner conforming to the excellent traditions for which M. Majorin professed a deplorable disdain.

André arrived with a supply of engravings and drawings in his own style, knowing that Jean was certainly "launched," as M. Mellinot said, "upon the domain of art." Jean was none the less eager to show his sketch-books to his foster-brother.

As for engravings or drawn models, he had no more than when his father, Loupeau, took him in a wagon to Hay; therefore, after breakfast, when André, spreading about twenty pictures and copies before Jean, asked him to show his patterns and drawings, Jean blushed slightly, and stammered out that his patterns were everywhere and nowhere, and showed his sketch-books, already tolerably well filled with geometrical figures, descriptions, and outlines of every kind, of which André really understood nothing. But the first embarrassment caused by this new way of studying art lasted but a short time; the two children visited the garden, and André in his turn became rather confused on hearing Jean name the plants, and explain to him some of their properties.

During this time Mme. Mellinot had obligingly placed herself at the service of dame Orphise to discuss some grave culinary questions concerning the evening meal, and M. Mellinot was sitting with his friend in a shady path, waiting for the heat to subside and permit a walk towards Sceaux.

"So, then," said M. Mellinot, "you think that Jean really possesses the qualities of an artist?"

"My dear friend, I do not say that: I mean that my foresight has not deceived me, and that this child is naturally an observer, and has a true eye, and by governing myself so as not to discourage this inclination, but, on the contrary, to develop it, I can give him a trade, and open

an independent career to him, even if it be only that of an excellent workman. I shall not attempt to make an artist of him: he will be one if his tastes so incline him. I shall merely put him in the way of being a useful man."

"Are you very sure that in not restraining, but rather in developing, as you say, what you call Jean's inclination for art, you will make him a useful man, and open an independent career for him? Do you not fear, on the contrary, that you will place him among the class who are misunderstood, and have no defined position, who?"—

"Permit me to stop you at your starting-point. I know no more than the child himself whether he has any inclination for *art*. He does not know what art is; and it is by no means a question of art, which, so far as he is concerned, does not exist."

"But yet you say that you make him draw, and that he shows a taste for drawing."

"Why do you not add to this remark that drawing is a fascinating art?"

"Ah, it is easy for you to get provoked! I know that drawing is an art, and that, in teaching it, you teach an art, or how to follow what are called the arts. All the reasoning in the world will not prove the contrary."

"Pardon: a simple comparison, in my opinion, will convince you that drawing, taught as it should be, no more leads a child to become an artist, than instruction in the French language leads him to become a poet. It

is not my fault if drawing is generally taught as seeking for its end a devotion to art. To me, drawing is simply a mode of recording observations by the aid of a language which engraves them on the mind, and permits one to utilize them whatever the career he follows. Allow me to give you an example. One would hardly suppose that drawing would be useful to a magistrate; and yet how many judgments would be established on more logical premises, if, in civil suits concerning joint-property, the division of inheritances, or the responsibilities of an architect or a contractor, the judges could comprehend a plan. You should have heard certain lawyers plead for hours, and the public minister discuss these questions from the testimony of experts whom lawyers and judges understand very imperfectly, to know to what degree the educated classes are ignorant of the language of drawing.

"A certain magistrate, in his youth, at college successfully copied perhaps the head of Romulus after David; but it was impossible for him to understand a plan or a section, to grasp the meaning of a geometrical figure, or to furnish the most elementary sketch, the better to explain his thought."

"If you propose to limit yourself to teaching your pupil geometry and the really useful part of drawing, nothing could be better, and it may be of great help to him; but it is not necessary to give yourself so much trouble, and to assume a burden, as our system of public education takes care of this."

"I do not know whether it takes charge of it, and has it at heart: I judge from results only; and, between ourselves, they do not amount to much, and perhaps even give false ideas."

"Always the same, my worthy friend: always ready to throw a stone at our system of instruction. You are infatuated with drawing; and you would perhaps like to have the children in our academies trained to draw only cubes and cylinders, ornaments and plants" —

"You know very well that such is not my idea. I wish only that children should be taught to use the pencil as they are taught to use the pen, to aid them to understand what is explained to them. Let us reason a little, if you please. At your academies you have translations of Cæsar's Commentaries, and there is nothing better; but do you think that the children who put this Latin masterpiece into bad French have the least idea who Cæsar was, and what were his legions, their manner of encamping, their tactics, and their armament, their implements of war, the countries where they fought, the appearance of the cities they besieged, and the means of defence of their enemies? They will learn this later, you answer (if they ever learn it). But why not while reading the text?"

"You might wish, perhaps, that the professor hearing the translation of the Commentaries, should not be contented with correcting the versions, but should have a

part of his class draw on the blackboard Romans and Gauls, catapults and ramparts."

"That professor might do it in a way that, as I see, would not do much harm; for he would then evidently be in a condition to better explain the text. But that is not what I would have. I should wish, for example, to make those children or young people copy, instead of drawn models which mean nothing to them, models in relief representing a Roman *vallum*, a Roman war-implement, a rampart, the arms of a soldier of the legion, and the equipments which were used at that time; and I would have them copy the map of the battle-fields, with the position of the forces, and a Gallic town or a Roman camp in the foreground. Do you not think that in proceeding thus these children would render their translations with more enthusiasm and intelligence, and that they would be more attentive in the drawing-class?"

"All that is very fine in theory, dear friend; but where do you suppose that our academies could procure all these fine things, without counting the expense of such an outfit?"

"Pshaw! talk to me of expense. Should a few thousand francs more or less be thought of when the question of instruction is considered, and when one may form these young minds in five instead of eight years, and give them the habit of observation and true ideas instead of imperfect or false ones? Do you not think this would be worth

the trouble of adding thirty thousand francs more a year to the appropriation for public instruction? When I say thirty thousand francs a year, to realize this improvement in education, I overstate it. I will undertake to carry it out at that price if you wish. The first expense of the models being incurred, the casts would cost very little.

"But no: there is the usual routine; since Rollin's time, to speak only of antiquity, our knowledge of the ancients has greatly increased. We know more exactly to-day how the Romans lived, governed, and fought than we do in the case of the French under Philip Augustus. This mass of information does not enter into education, but stands at the threshold of the outer door, at the service of the very rare minds whose tastes lead them to serious historical studies."

"Good! But here we are far from the opening of our conversation. There would be too much to say on this subject to answer you, so let us return to our starting-point. You do not intend to send Jean to college, at least at present; but, if I am not taking too great a liberty, will you allow me to ask what method you intend to adopt in the present case? If I ask you this question it is for my own information; for I do not quite comprehend your way of carrying it out, nor the end which you are seeking."

"Very well; I will state it in detail. In the study of

drawing there are two elements, — physical labor, the exercise of the eye and hand; and intellectual work, that is, the habit of observing with exactness, and engraving on the memory what one has observed, so that the mind can compare, and draw deductions from the comparison.

"The method which consists in placing before the eyes of the pupil graduated drawn models, and in beginning by the simplest outlines to successively reach a head or a modelled ornament, may be good to accustom the hand of the pupil to copy these models mechanically, but in what way does it exercise his understanding? In what way can it even give knowledge of the objects copied? The pupil sees in them only flat pictures, composed of white, black, and gray, which he must mechanically reproduce. Does he consider the planes and the light and shade of the figures? Hardly more than the sheet of glass in photography considers the effect of the solar rays on the substance which covers it.

"From these pupils choose the ablest, those who have obtained prizes, and have succeeded in reproducing an engraved pattern with such perfection that one would take the copy for the original, and suddenly ask them to draw a bottle from memory, one of the most simple and common objects, and they will give you only an imperfect sketch.

"Then of what use is the trade you have given them. When their studies are over, it never occurs to them to

take a pencil to represent an object whose form they would describe; they never think to make a sketch which will remind them of a scene, a place, a piece of furniture, or a tool. And why? Because they have never been taught to see; and one learns to see only by drawing, and not from engraved patterns, but from objects themselves; and further still, only on condition of being able to explain these objects, and to describe their properties, and their relations to each other."

"It seems to me you exaggerate a little, for how many can we count in the first rank among skilled observers who are unable to draw!"

"Yes; but do you know at the price of how close attention they succeeded in grouping their observations, and how long it took to draw deductions from those observations which were with difficulty fixed in the memory, on account of their inability to draw them? And, in regard to the observers of whom you speak, has not photography come just in time to give a singular development to their studies, and to the conclusions drawn from them? and do you not believe that drawing is now just as necessary, not on account of the pleasure of collecting pictures in portfolios, but because drawing accustoms the eye to see more quickly, more justly, and better, while establishing between the organ of sight and the brain a kind of joint work which facilitates deductions?

"We pass before an object a dozen times, and look at it attentively because it interests us, and we think we are perfectly familiar with it in its general form as in its details. Some day we take a notion to draw it, and discover qualities that we did not suspect, though we had firmly determined to closely observe. One who has acquired the habit of drawing without fatigue, without being obliged to make an effort, as one writes, *draws* all that he looks at attentively; or, in other words, while looking he performs what he would do if he wished to reproduce the object on paper.

"You understand that it is not a question here of art and composition, or of producing works worthy of Raphael or Leonardo da Vinci; but of contracting a habit and establishing an intimate relation between the eye, brain, and hand, so that one of these organs can never receive an impression without the other two being able to second it.

"To return to these learned observers just spoken of: it has frequently happened to me to be brought into contact with many of them: well, although I do not pretend to be either a *savant* or an artist, I have often pointed out to them facts which they did not suspect, simply because, being accustomed to draw, I had looked at certain objects in the vegetable, animal, or mineral world, as if it were necessary for me to draw them. Because the majority of our distinguished *savants*, without being able to draw,

have reached high positions, it must not be concluded that drawing would not have facilitated many of their researches, or have enabled them to save much time.

"I hardly know a career in which drawing would not be useful, if not absolutely necessary, for the very simple reason that it teaches one to see correctly, to remember what one has seen, and to give a form to thought.

"I do not claim to be able to make an artist of Jean: he will become one if he has it in him. I propose only to teach him to see correctly; to consider what he sees, and to render it so that his observations may serve him, whatever the career he follows, whether that of a workman or a soldier, merchant or lawyer, artist or engineer. It is an experiment which cannot in any way injure his future; but taking drawing as a medium, — or, as I understand it, the habit of observing, comparing, and reflecting before advancing an opinion, — I intend to develop his mind, nourish his intelligence, and give him a taste for learning."

Was M. Mellinot convinced of the practicability of the method adopted by his friend? By no means. He thought that all these ideas were only the confused fancies of an odd brain. This manner of education through a *habit of observing*, according to M. Majorin's expression, seemed to him the aberration of a mind that was more generous than clear-sighted; so he hazarded this single objection: "Do you not think, my friend, that before

placing the judgment of a child above what you call observation, the judgment must first be formed? To observe well — since one has to observe — you must have good organs: and what are they in a child? Are they not imperfect and partly formed? Are you sure that the child to whom you explain facts or phenomena in the simplest manner possible, understands what you say to him?"

"I try to have him; but I admit that children are much more apt than is generally believed at understanding, not abstractions, but facts, and the causes of facts; then, in many cases one can throw a healthy and virile seed into the child's mind, and, though sometimes it is slow to germinate, it is rarely lost. You tell me that to observe well, one needs a ripe judgment. I do not deny that; but to form it, it is necessary to observe much; and thus we reason in a circle. You pretend to form the judgment of a child by cramming his mind with a heap of things, which have only a remote relation to what he sees every day. You teach him languages that are no longer spoken, you require him to study authors who belong to a civilization which no longer exists, and tell us of things wholly foreign to our habits and customs.

"He knows something of the government of the Roman republic, and tolerably well the causes which established the empire of the Cæsars and the fall of the republic of Athens; but he does not know, and will not till his

twentieth year, what is the form of the government under which he acquires this knowledge.

"I should see no harm, and could even see much good, in that, if, at the same time, the child were made acquainted with the civilizations among which these events of the past took place, and how they are the logical sequence of the civilized state where they occurred, if, at the same time, these young minds could be brought to the realities of the present, with which they will soon come into rude contact; but is it thus that one proceeds? Is it forming the judgment of the young to isolate them intellectually — in the state where they will be called to live?

"I am far from opposing our university education: in certain respects I find it even too perfect and too replete; the pupils are in the condition of tubes pierced at both ends, through which a rapid current of studies passes, entering by one orifice to be ejected through the other; but, in this current, I do not see very well what there is of a nature to form the judgment, since, in my opinion, observation alone can give such a result. I do not know what I shall do with Jean when he has grown up; I shall think about it: but I believe, that, whatever may happen, the habit of observing and reasoning which I have been able to form in him while a child must be very advantageous to him, even if I send him to college."

After this last remark, the friends joined Mme. Mellinot.

They called the two children, who also seemed very busy with their affairs, and together they rambled through the fields until dinner.

In the evening, on returning to Paris, André said to M. Mellinot, —

"Father, I would like to learn to draw like Jean: it must be very amusing; one sees all sorts of things — everywhere. He knows the names of trees and flowers, and also of tools, and for what they are used; he has made *solids* — as he calls them — out of pasteboard, which are very pretty, and little houses. He showed me a large drawer full of them."

"That is well, that is well," answered M. Mellinot: "we will see about it — when you are older."

"But Jean is not any older than I."

"Jean has not the same studies to pursue as you: to enter a workshop, or to work in the fields, he will know enough from what he learns at school, and from what M. Majorin teaches him."

"But that makes no difference. I would like to learn what he does: he told me whatever M. Majorin taught him was always interesting, — and," thought André to himself, without daring to say it aloud, "what is taught me at school is not always made interesting."

In a few weeks M. Mellinot, having met the professor of drawing in the institution where André was placed, asked him if he was still satisfied with his pupil.

"Not so much as at first," answered the professor. "André is more inattentive in his class, and wastes his time scribbling on the margin of his paper whatever he happens to see around him. The other day I was very much surprised to see him sketch his comrade who sits on the bench opposite him. All this indicates natural inclination perhaps, but might spoil his touch: his copies from patterns are neglected, and he does not take the trouble to finish them."

"Have you spoken to him about it?"

"Certainly."

"And what did he answer?"

"As well as I could understand him, he wished to draw from nature. 'You will in time,' I said to him; 'but you must first draw from patterns, to know how to set about it. You notice that in the evening classes,' I added, 'adults draw from plaster models. They can do it only after long practice in copying drawn patterns.' But, for the time being, your son seems to me to be turned aside from the serious study of drawing: however, I am quite satisfied with him."

"That," said M. Mellinot, "is the first fruit of the lessons given Jean by that devil of a Majorin. After all, it matters little whether André is more or less devoted to copying pictures. I have no desire to make an artist of him."

CHAPTER VII.

A LITTLE OF PERSPECTIVE AND DESCRIPTIVE GEOMETRY.

WINTER having come, they could no longer go into the garden to study plants, or discourse on light and shade. Jean began to draw tolerably well every simple object that was placed before him; but he could not easily explain irregularities in perspective. M. Majorin, having given him a few ideas of geometry, thought the time had come to teach him the first elements of perspective.

Therefore he said to him one evening as he drew the diagram (Fig. 29) on the blackboard,—

"You see these two stakes, A and B, A being shorter than B. If you place yourself at C, you notice that this stake, B, is longer than A, since you see B above it; but if you stand at D, the stake A seems larger than the stake B. Therefore the apparent size of objects is in proportion to the distance of your eye from them. As you approach, they seem to increase in size, and to diminish

as you recede. Well, there is a sure way of ascertaining exactly how much these objects diminish as you recede. But in the first place you must perfectly understand what a table, or perspective plane, is.

"A table is a flat surface, the vertical plane interposed between objects and yourself, and on which they are pictured. It is the glass pane through which you look. If you do not move your head, and step back from it the length of your arm, it will be easy for you to draw on it, with a pencil, all that you see through it.

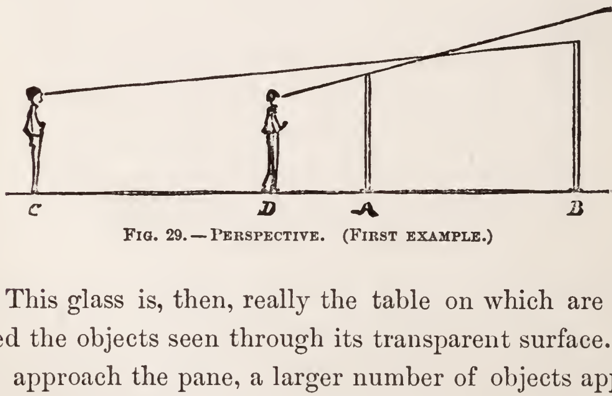


Fig. 29.—Perspective. (First example.)

"This glass is, then, really the table on which are pictured the objects seen through its transparent surface. If you approach the pane, a larger number of objects appear to you in its frame. If you recede, you will see fewer of them. The distance of your eye from this table regulates the extent of ground within its frame. But your eye, unless you turn the pupil to the right or left, or up or down, can take in only a cone whose vertex makes an angle of nearly forty-five degrees. So that if you stand

at A (Fig. 30) the table or glass pane must be within B C (the angle A being forty-five degrees), for you to take in at a single glance all that is on its surface. If this table, or pane of glass, is at *b c*, you will see at a glance only what is in the angle of vision, that is to say, the objects within the field, *e f;* and to see what is on this table from *e* to *b*, and from *f* to *c*, you must turn your eyes to the right and left or towards the top and bottom: remember this well.

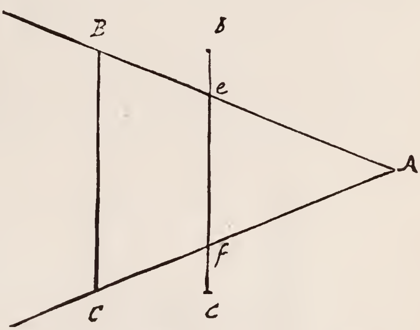


Fig. 30.—Perspective. (Second example.)

"But you know that the horizon is always on a level with the eye, therefore upon the table or the pane it is also on a level with the eye, and the shortest line, falling from your eye to this table, and perpendicular to it, will meet this horizon line at a point which is called the point of sight, or principal point. To have you perfectly understand what the principal point is, suppose (Fig. 31) a looking-glass to be at *a b c d*, and yourself standing at A. You will be reflected in the glass at B, will you not? Suppose, again, that you mark on this glass the point O, where your eye is reflected, and draw a horizontal line, *h i*, passing through this point: you will have at *h i* the horizon,

and at the point O the principal point; so that, if one should instantly remove the quicksilver, and leave the glass transparent, you would have a view of the sea or plain, the line *h i* would fall exactly on the horizon, and at the point O all the lines beyond the glass, parallel to the line A D, or perpendicular to this glass, would converge. But this question of the table or glass through which one

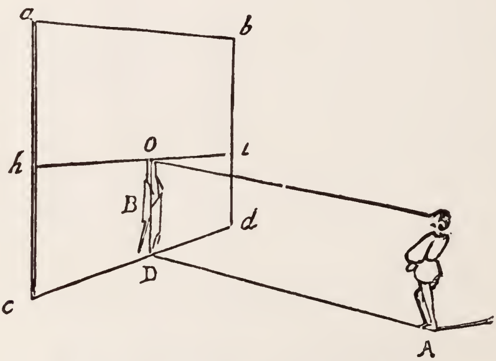


FIG. 31.—PERSPECTIVE. (THIRD EXAMPLE.)

sees objects is important enough for us to urge its study; for when one understands the important part this pane of glass fills, he knows perspective, and can solve the most complicated problems. Follow me attentively. Here at *a b c d* (Fig. 32) is a mirror and a pane of glass, and at *e f g h* a wooden panel. You stand at A, and the horizon will then be at the height of your eye, on the pane of glass at *l m*, and your point of sight or principal point at O.

"Supposing that you can extend threads from your eye, and meet the two lines *e f*, *g h*, they will pierce the glass from *e′* to *f′* and from *g′* to *h′*. Thus you will have on this pane of glass the perspective representation of the panel *e f*, *g h;* the two parallel lines *c g*, *d h*, will be defined on this glass at *c g′*, *d h′*, and these two parallel lines *c g′*, *d h′*, will reach to the point of sight O.

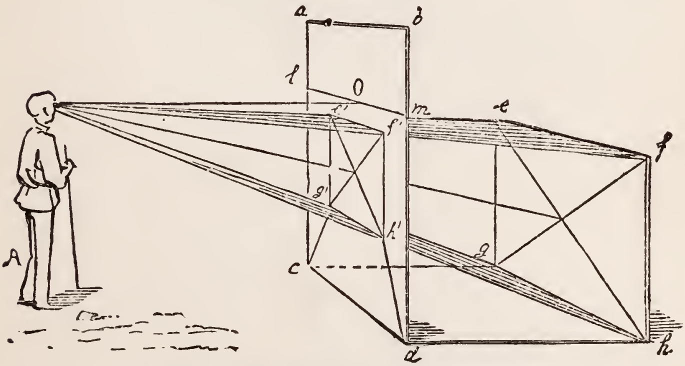


Fig. 32.—Perspective. (Fourth example.)

"But this explanatory figure does not in reality give you the appearance of the panel *e f g h*, since, to make you understand the illustration, I have placed the glass and panel in perspective. What you need to know is, standing at A, what figure this panel, or any other object beyond the table, would make on the glass or table.

"Well, suppose that *a b* (Fig. 33) is the trace of the glass on the ground, and it is but a line. You are at A,

and this point A is the foot of the vertical falling from your eye to the ground. It is what is called a *vertical projection.*

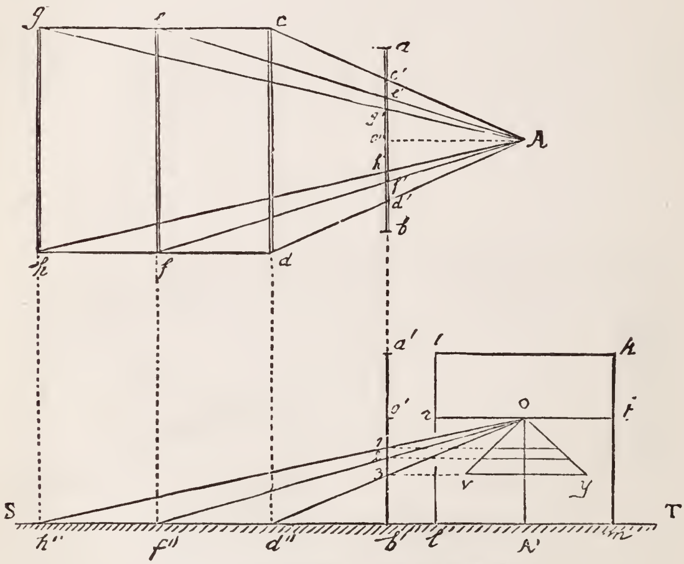


FIG. 33.—PERSPECTIVE. (FIFTH EXAMPLE.)

"Suppose again three rules, *c d*, *e f*, *g h*, equal to each other, equidistant and parallel to the line *a b*, and so drawn that they are contained between two parallel lines, necessarily perpendicular to the table *a b*. If from your eye, whose horizontal projection is at A, you draw lines to the extremities of each of the rules, these lines will pierce the table or pane of glass at *c′*, *e′*, *g′*, *h′*, *f′*, *d′*, which

will show you at once that these rules, which are equal to each other, will appear smaller and smaller on the pane of glass as they recede from your eye.

"Now, let us raise this glass *a b*, and consider the ground divided as in S T, and perpendicular to the glass.

"This glass is shown by a line $a' b'$, and the rules *g h*, *e f*, *c d*, will be only the points h'', f'', d'', on the ground. You stand at A, your eye is at O, and the point of sight on the intercepted glass at o'. If from the point O (your eye) you draw lines joining h'', f'', d'', these lines will cross the glass at 1, 2, and 3.

"Having done this, face the table, which will be the parallelogram *i k l m*, *l m* the ground-line, *r t* the horizon, and O the point of sight; carrying 1, 2, 3, back to the table by parallels, you have the position of the three rules in perspective, and continuing on both sides of the vertical O A′, along the line 3, the lengths $o''\ c'$, $o''\ d'$, o'' being the horizontal projection of the point of sight; along the line 2, in the same way, the lengths $o''\ e'$, $o''\ f'$; and also along the line 1 the lengths $o''\ g'$, $o''\ h'$; you will see that these lines are thus contained between the two lines *v* O, *y* O, which are the parallels *c g*, *d h*, in perspective.

"Then, to place an object in perspective, you must know the distance of your eye from the table, and, carrying back this distance on the horizon-line, you suppose the pane of glass or table to be in profile, as at $a' b'$, and you make the illustration which I have just shown you.

"You will ask me, perhaps, how it is that all the lines parallel and perpendicular to the table extend to the point of sight. This is an optical phenomenon which is owing to the construction of the eye itself, which perceives objects only through an extremely small orifice, and reflects them in a concave mirror back of this orifice. Hence it must be that the parallel lines are united at this point like so many rays. In a word, you see nothing in nature *in perspective:* it is your eye which causes the perspective; and, if you wish to reproduce to other eyes than yours the appearance of these objects, you must draw them according to the laws of sight."

"Do animals also see in perspective?"

"Without doubt, — at least the higher animals: it cannot be otherwise.

"They all more or less have an idea of distance, a more or less clear and extended vision; and there cannot be a different perspective for beasts than for men, only they do not learn the laws.

"Man not only discovers and defines the laws of perspective, but he deduces from them the knowledge of size, and the true position of objects of which he perceives the appearance only inversely, as I will show you.

"Let us try to put a square in perspective, without making further use of all these figures that are drawn, that you may understand how an object is pictured on a glass interposed between yourself and the object (Fig.

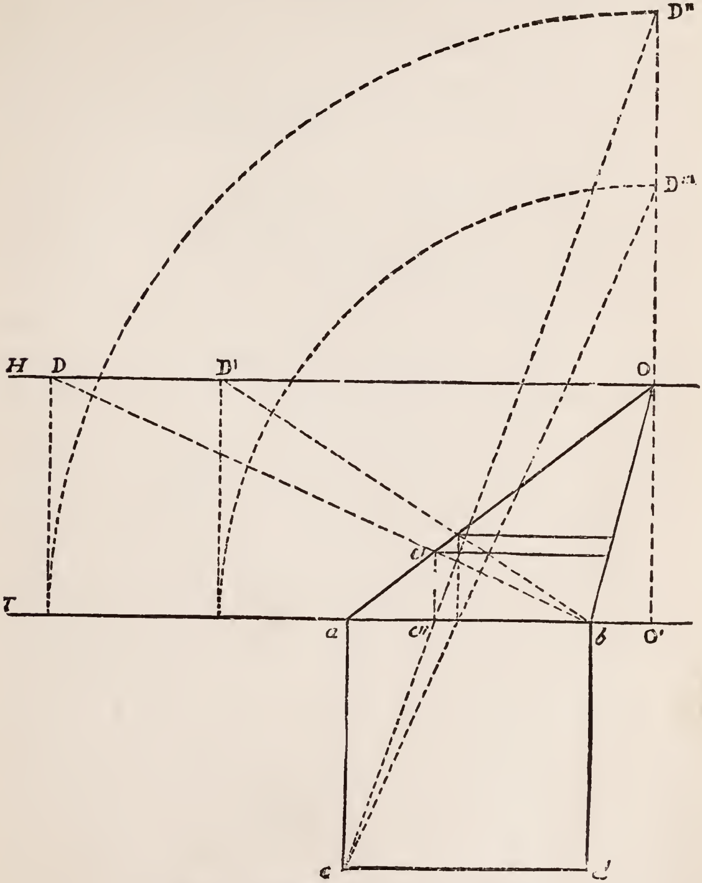


FIG. 34.—PERSPECTIVE. (SIXTH EXAMPLE.)

34). We have a square *a b c d:* the ground-line, or the line of meeting of the table with the ground, is at T, the horizon at H, and the point of sight at O. Do not forget

that this point O is the projection of your eye along the horizon, the meeting with the table or glass pane of the perpendicular line which falls from your eye to this table. The distance from your eye to this point O extends to D on the horizon.

"To put in perspective the two lines *a c*, *b d*, which are perpendicular to the ground-line, it is sufficient, after what I have previously demonstrated, to draw two lines from the point *a* and the point *b* to the point of sight: we have thus the two sides *a c*, *b d*, of the square, in perspective; but we must know where the side *c d* will cut the two lines *a* O, *b* O. The position of this line *c d*, in perspective, will depend upon the distance at which we are from the table or pane of glass; for it is evident that the nearer we approach this glass, the more depth the square will seem to have; and, the farther we recede from it, the more shallow it will seem to be. Therefore, the distance from your eye to the visual point O, being extended to D, the illustration previously shown you has proved that the distance from a point to the table is shown on this table or glass by a line which was drawn from your eye meeting this point. Therefore, the distance *a b*, the side of a square, being equal to the distance *a c*, if from the point *b* we draw a line to the point D, which is on a line extending from the eye along the horizon, the intersection of this line *b* D with the line *a* O will give the point *c′* in perspective, and, consequently, the line *c d* in perspective.

If you approach the table, keeping the distance of your eye from it no more than the length D′ O, and make the same line as above, that is to say, drawing the line *b* D′, you see that your square in perspective has apparently more depth.

"But you must familiarize yourself with these illustrations of lines piercing planes, and the cutting of planes in every direction, and you must perfectly understand the elementary problems which I explain to you, for in them lies every thing. And, having understood these elements, the rest comes of itself.

"The ground-line, or rather the trace of the table on the ground, being the line T, the distance where you will be from this trace will be equal, as has been said, to O D, and consequently to O′ D″, the point D″ being the horizontal projection of your eye on the ground. If, then, you draw a line from this point D″ to the point *c*, the angle of the square, this line will be the horizontal projection of the visual ray coming from your eye and reaching to the point *c*, and it will cross the vertical plane of the glass at *c*″.

"Now, you see that if you raise a vertical from this point, *c*″, it will exactly meet the point *c*′, which will give you, in perspective, the depth of the square. It will be the same if we proceed from the point D,‴ nearer the table. Therefore the point *c*′ is really the point where the line drawn from your eye to the point *c* pierces the glass. This will enable you to understand in a very clear

manner, the sketch (Fig. 35) which the glass presents, — the square horizontally placed, the horizon at H, the ground-line at T, the point of sight at O, and the perspective representation of this square on the glass given by the points of meeting of the lines drawn from your eye

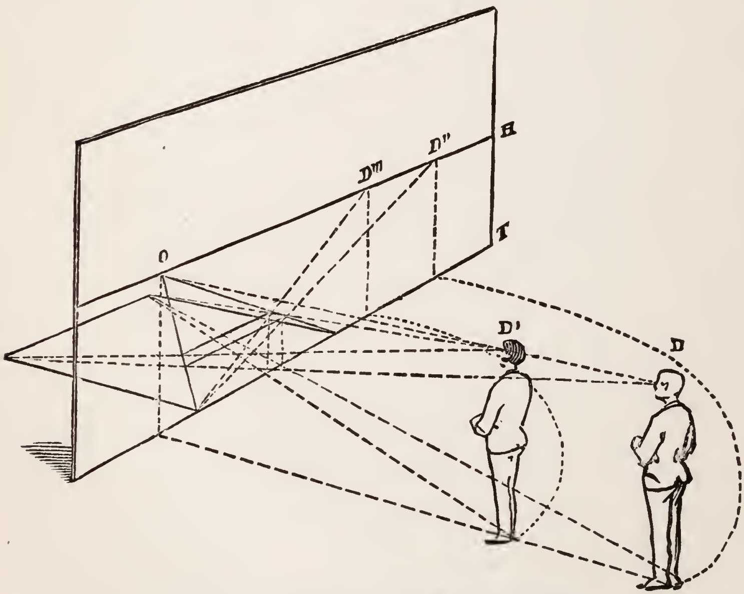


Fig. 35. — Perspective. (Seventh Example.)

to the angles of the square, according as you are more or less distant from the table; and, again, the extending of the points of distance D D′ to D″ D‴ on the horizon drawn on the glass, and finally the illustration of the preceding figure."

M. Majorin gave other demonstrations: with cut pasteboard, a very fine wire-gauze, and threads, he made Jean understand how solids look in perspective on a table. For example, he placed a pasteboard cube at A; then, placing a very fine wire-gauze between it and the spectator B (Fig. 36), he passed threads extended from the angles of

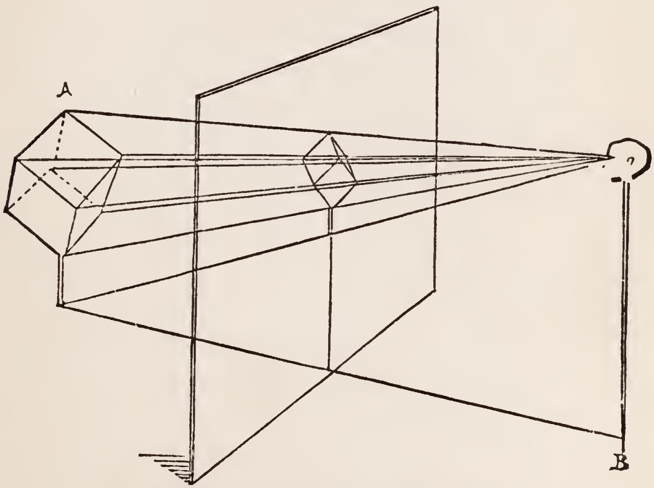


Fig. 36.—Perspective. (Eighth Example.)

the cube to the eye of the spectator; and the intersection of these threads with the wire-gauze, permitted him to draw on the latter the perspective of this cube.

M. Majorin persevered a long time with his pupil, till he perfectly understood these intersections of lines and planes with the vertical table.

The teacher was very particular to familiarize Jean with these elements of perspective. Without wearying his young mind, he often returned to these problems, while occupying him in the interval with questions which required less attention.

He thought that before attempting the simplest elements of descriptive geometry, it was well for the pupil to have a very exact idea of the effects of perspective, that is to say, of the true appearance of objects. He said to himself, that, in order to understand the geometrical projections on a vertical and a horizontal plane, it was necessary, in the first place, that the eye and mind of the child should no longer have to make an effort to comprehend the position of a body, point, or line in space; and, before giving theoretical definitions, he gave examples. Thus, with pieces of pasteboard he showed Jean how a plane could cut two other planes at a right angle, and said (Fig. 37), —

"You see this plane, *a b c d*, called the vertical plane, and this other, *a b e f*, a horizontal plane. This pasteboard, *g h i*, pierces these two planes, and leaves on them a trace, *h g*, which is the vertical trace, and another, *h i*, which is the horizontal trace." Then, raising the pasteboard, *g h i*, he unfolded the two planes as one sees at A, and showed Jean the two traces.

"Thus," he added, "one knows the position of a body, a plane, or a point, in space by the trace or the pro-

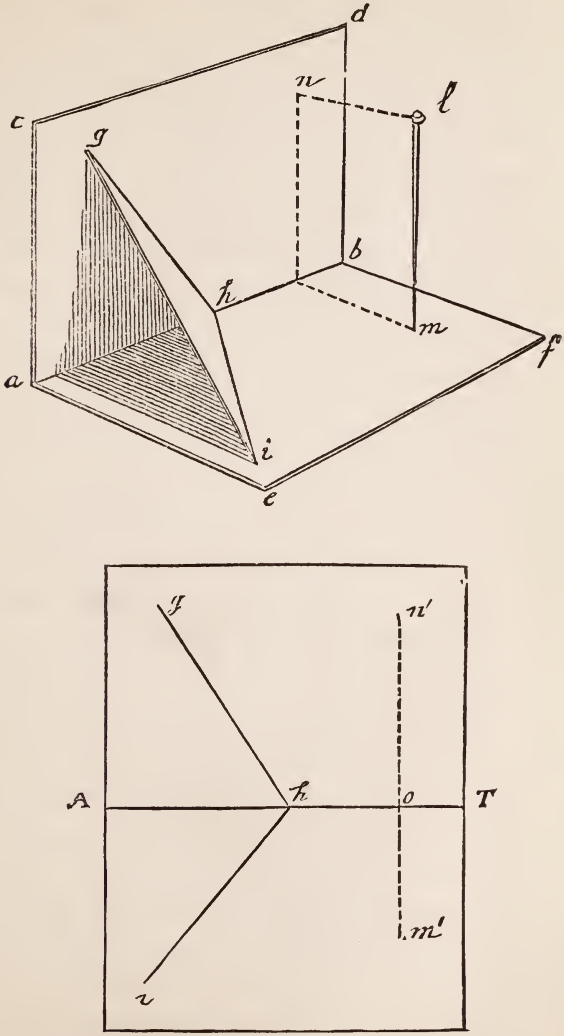


FIG. 37.—PERSPECTIVE GEOMETRY. (FIRST EXAMPLE.)

jection which it leaves on the two vertical and horizontal planes. Here is a point" (and saying this, after folding the two pieces of pasteboard, he fastened a long pin, *l m*, into the horizontal plane), "*l* the head of this pin. Supposing the body, *l m*, perfectly vertical, *m* is the horizontal projection of the point *l;* extending from this point *l*, a line *l n*, horizontal, and consequently parallel to the horizontal plane, and perpendicular to the vertical plane, we prick another point, *n*, in this vertical plane, a point which is the vertical projection of the point *l*." Then, unfolding the pasteboard again, he showed that the two points m' and n' were naturally perpendicular to the ground-line A T.

Then he added, "I thus know the exact position of the point *l*, or of the head of a pin, in space. I know that it is at the distance $o\ m'$ from the vertical plane, and at the distance $o\ n'$ from the horizontal plane."

M. Majorin showed Jean how one can pass a plane through a point. "Suppose," said he (Fig. 38), "the ground-line T, and on a vertical plane the trace (*a b*) of a plane. Suppose at *o* and o' the vertical and horizontal projection of a point in space: we must pass the plane *a b* through this point, and give the trace of this plane on the horizontal plane. We draw from the point *o*, — the vertical projection of a point in space, — a horizontal line till it meets with the trace *a b* at o''; from the point o'' we lower a vertical which will meet the ground-line o'''; we

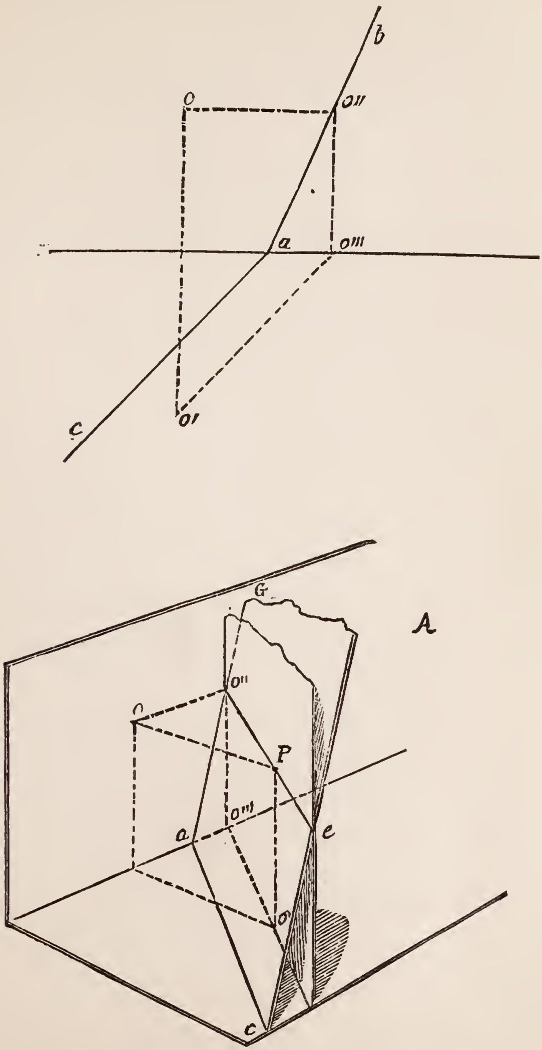


FIG. 38. — PERSPECTIVE GEOMETRY. (SECOND EXAMPLE.)

unite the point o''' to the point o', the horizontal projection of the point in space; we have thus passed through this point in space a vertical plane whose horizontal line will be o' o'''.

"Hence we have the horizontal trace of the plane a b, which must pass through the point in space; for this line will be parallel to the line o' o''', which we indicate in a c."

M. Majorin, by means of his pasteboards, had little trouble in making Jean understand the operation (see *a*), which consisted in passing a vertical auxiliary plane through the two vertical and horizontal projections o'' o''', o''' o', which vertical plane should necessarily meet the plane a b, following the vertical projection o o'', and give the horizontal trace a c, parallel to the trace o''' o'. The point P, being on the line of intersection, o'' e, of the two planes, is in the planes a G c; therefore this plane passes through this point.

To say that these demonstrations were perfectly understood by Jean, would be going too far; and M. Majorin was not deceived regarding it: his method evidently consisted in giving his pupil a glimpse of the ground he had to go over, leaving him free to retrace his steps, and to fill up the gaps by means of daily observations, and to make use of every opportunity to show the various applications of a problem that had been solved. Jean gradually acquired a knowledge of the intersection of

planes, and matters of perspective. M. Majorin would ask him a question, and, though putting him in the way to understand and answer it, would leave him to study the subject himself. One evening he drew a circle, and asked him to put it in perspective.

"You know," he added, "that a circle is contained in a square: now try to put a square in perspective."

Jean took great pains, complicated figures, blundered a good deal, and did not succeed, and M. Majorin came to his aid. (Fig. 39.)

"You have placed the square containing the circle in perspective; you see that this circle touches the sides of the square at four points; you have, therefore, in perspective four of the points of the circle, which are the points *a b c d*. This is not sufficient to represent it. Well, draw the diagonals of the square, and you will still have four points of the circle, *e f g h:* these diagonals are in perspective, if you unite the points *n o p q*. Good! there you have it."

Indeed, Jean drew the lines *i k*, *l m*, which he carried to the point of sight V, and their intersection with the diagonals gave him in perspective the other four points of the circle. M. Majorin showed him by the drawing X that there could still be as many other points as were necessary, so as to draw the circle in perspective; then raising a vertical line on the centre of the circle of the perspective, he drew from the point S, fixed above the

horizon on this line, one parallel to the horizon, then a line at the point of sight; and raising other verticals

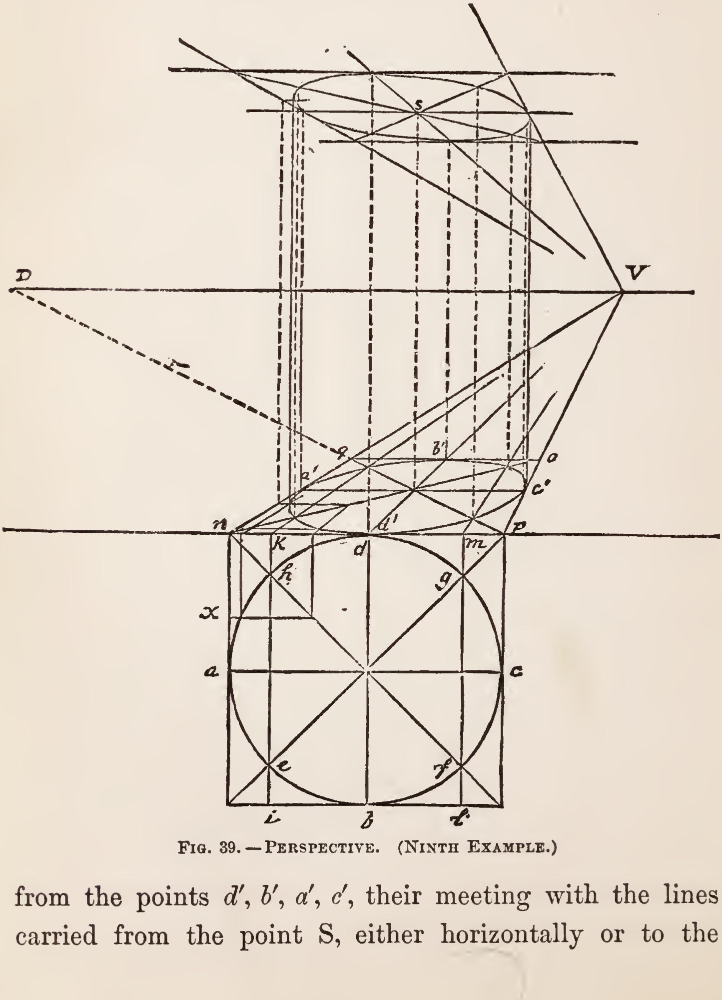


Fig. 39.—Perspective. (Ninth Example.)

from the points d', b', a', c', their meeting with the lines carried from the point S, either horizontally or to the

point of sight, permitted him to fix the limits of another square in perspective on a horizontal plane at the height of the point S. In this square in perspective he drew the two diagonals, and raised verticals from the points of intersection of the lower circle with the diagonals of the first square, which gave him, in the upper square, the points through which the second circle must pass; and, having done this, he made a drawing of it.

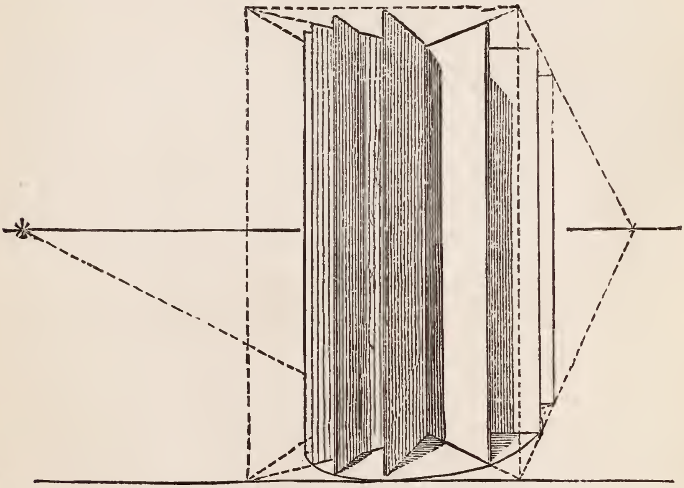


FIG. 40.—PERSPECTIVE. (TENTH EXAMPLE.)

"Thus," said M. Majorin, when the illustration was finished, "we have put a cylinder in perspective.

"What have we done? We have passed vertical planes, like the leaves of a book, around the axis of the cylinder, as Fig. 40 represents; and we have only to pass circles

touching the upper and lower angles of the leaves, to determine the cylinder."

Thus Jean passed the winter evenings in perfecting himself in the study of the elements of geometry, descriptive geometry, and perspective. In order not to fatigue him, these lessons were varied with others, during which the teacher made him copy objects, solids, and parts of machinery, and small blocks of pasteboard placed in every position, so that the pupil had them first below his horizon, then above (Fig. 41). M. Majorin did not fail to correct the errors in perspective, taking care to explain wherein the pupil had failed. It was an opportunity to study the accidental points that were always at the horizon, more or less distant from the point of sight, and to which the parallel lines converge, without being perpendicular to the table.

These lessons were seldom given without M. Majorin having occasion to explain to his pupil some curious phenomena concerning optics, and light and shade, in order to keep his mind constantly active, and to form the habit of observation.

In one of these conversations, he showed how the relations of the dimensions of the stories of a tower, for example, can be entirely modified according to the position of the spectator. (Fig. 42.)

"You can easily prove," said he, in this conversation, "that this tower is composed of stories, whose height varies very much.

Fig. 41.—Group of Buildings seen from two different points of view.

"However, if you stand at A, and examine this tower, its stories will be pictured in your eye, which is only a point, the centre of a sphere, a segment of which I draw at B C. Suppose this segment to be divided into equal parts, *a b*, *b c*, *c d*, &c., these stories, which are so different in height, will be pictured in your eye as if equal; the divisions *a b*, *b c*, *c d*, &c., being equal to each other. By reasoning you will understand that these stories are not equal: but reasoning here causes an illusion; for, if you faithfully copy the tower, it will have the height only of the drawn line *f a*, and its perspective appearance will be that indicated by the sketch T. The farther you move away, the more the stories will resume their relative dimensions; and, the nearer you approach the foot of the tower, the more they will lose them, as the position A′ of the spectator shows; so that, to the spectator who is placed at A′, the tower will be pictured in his eye as indicated by the sketch T′.

"But, better still, if you are at a great distance from a tower at O, although the point S, the summit (see M), is more distant from your eye than the point X, the upper side consequently appearing smaller than the side at the height of the horizon, you hardly notice it in the perspective sketch, and draw the two angle-lines of the tower parallel: but if you approach O′, there will be between the visual ray O′ X and the visual ray O′ S, comparatively a much greater difference in length; hence the

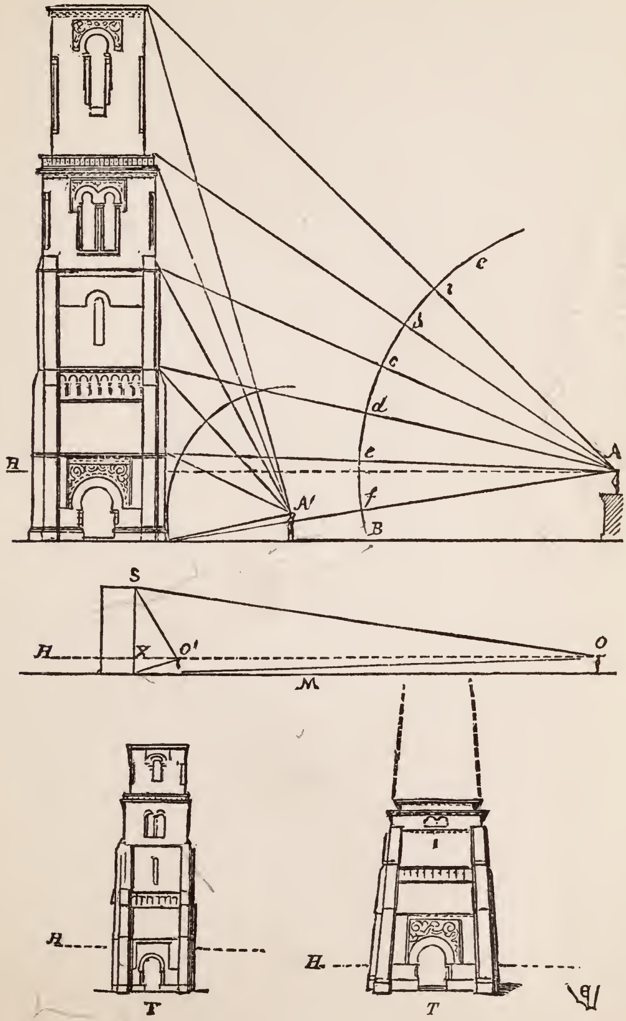


FIG. 42. — VARIATIONS IN PERSPECTIVE.

two parallel lines at the piers of the tower will recede towards an aërial point of sight, and the tower will appear to you thus (see T′). So photography, which gives no illusions, presents these irregularities when the object is at a short distance from the base of an edifice. The vertical lines tend to a point, and are no longer parallel; for one is obliged, in order to obtain the proof, to incline this object, as you are obliged, when you are at the foot of a public building, to raise your eyes, and no longer direct them to the horizon; for you seek that horizon, or rather vanishing-point, in the sky."

And thus every day M. Majorin revealed new phenomena of sight to Jean.

CHAPTER VIII.

JEAN BEGINS TO SEE.

WHEN, early in the spring, Jean was able to take a few walks with M. Majorin, it seemed to him as if he saw a new world.

If a child's mind is led to observe, a sudden development takes place in it, as when nature awakens under the rays of a spring sun. The child has a glimpse of splendors that charm him. He does not know why; but he has a boundless desire to penetrate the secrets of nature, which every day shows him new treasures.

Buds bursting their glutinous envelope, flowers peeping through the carpet of dead leaves, birds busily warbling about their nests, and the thousands of insects swarming in the grass, give birth to fruitful thought in the mind of a child, if one knows how to direct it. M. Majorin soon perceived that Jean looked at every thing with new interest: he congratulated himself on seeing his pupil profit by the lessons given him during winter evenings,

and felt sure he would be able to develop his talent. According to his habit, however, he wished him to take the lead to a certain extent; and, rather than to encourage him to new observations, he preferred to fill up what the child had outlined.

FIG. 43.—BUDS OF THE HORSE-CHESTNUT TREE.

One morning when Jean remained at home, M. Majorin, who was walking around the garden, noticed that he was very intent upon something in a cluster of bushes. Ap-

proaching softly, he saw that he was copying the open buds of a horse-chestnut tree (Fig. 43). Incorrect as were his sketches, his teacher felt real joy at this evidence of the fruit of his lessons. Jean was so busy drawing, that for a few moments he did not notice the presence of M. Majorin; and as soon as he saw him he blushed as if he had been caught doing wrong.

FIG. 44.—OPEN BUD OF THE HORSE-CHESTNUT.

"Very well done, my lad," said M. Majorin, smoothing the fair hair of Jean. "Are they not beautiful? What an effort those leaflets have made to throw off the gummy envelope which protected them from the cold, and how vigorously they open with the promise of a full development! Examine this bud, which has thrown off its brown glutinous scales: there remain only the four stipules of the base, which, having fulfilled their part, will also soon fall away. Look, here is one of the buds which has freed itself, its petioles are already separated; only the ends of the cluster of young leaves are still united (Fig. 44). Good!

here is a bud more in haste to expand; the leaves have separated, but the stipules, however, are still attached to the base; and here is the flower which is also in haste to bloom (Fig. 45).

FIG. 45.—FULL-BLOWN BUD OF THE HORSE-CHESTNUT.

"In a few days, if the fine weather lasts, all of them will be developed, the leaves will be of full size, and the clusters of flowers, that are to-day still sleeping, will proudly rise from their peduncles.

"But we must not linger too long with these important subjects, for among the small plants which spring up from the decayed leaves of winter there are many worthy of our attention. Less strong and hardy than the large plants, they bloom with greater difficulty.

Fig. 46.—A Cluster of Violets.

"Look at this cluster of violets (Fig. 46): notice how the leaves, which were at first rolled up like horns in order to enable their tender blades to force their way through obstacles, joyfully expand in the sunlight as soon as they

have finished their first task. But let us pass into the thicket. Last year there were a few clumps of ferns, and new shoots ought to have sprung up from their roots.

Fig. 47.—Root of Violets, Leaves, and Flowers.

"Ah! here is one which has cast off its covering of dead leaves; and, as the cluster of violets rolled up its leaves in horns, so the more hardy fern closed upon itself, and forced a passage. Is it not charming (Fig. 48), and was there ever a more beautiful gem? Is not that grayish-green bud, which folds its still downy and overlapping leaves, very graceful and beautiful?

"There are in this corner of the garden many objects to be drawn; and you must hasten, for your models will not wait. Nature is not like men and women sitting for their portraits: she does not pose, for she has other work

Fig. 48.—Buds of the Fern.

to do. However, she will give you time to take breakfast: you must come at once, for dame Orphise is calling us."

There are days in the life of children, as well as in that of men, when revelations come, and a rapid progress is made. What has been confusedly stored in the brain for a long time, but which is useless for lack of power to classify it, arranges itself as if by magic.

Our little Jean had reached one of these phases of mental development. At breakfast, in his mind, he placed the plates and decanters in perspective. He looked out of the window at the landscape, and drew it with an imaginary pencil. With the aid of a match he tried to draw on the tablecloth the figure of the cat curled up on a cushion (Fig. 49).

FIG. 49.—MINET.

M. Majorin noticed what Jean was absorbed in doing, and wishing to examine him said, —

"Tell me, my lad, is it not more than a fortnight since you went to see your mother and the rest of your family? It is so pleasant, I think I will go to Villeneuve-Saint-Georges, as I have an errand near there. Would you like to go with me to your father's?"

"Yes, sir."

"You do not seem very eager."

"Yes, I am, sir."

"No, you are not. The weather is delightful, and we will dine at Villeneuve, and return at night: does not that please you?"

"Oh, yes, sir!"

"But you assent without the slightest enthusiasm. Have you any plan, or any game with your schoolmates, in your head? Tell me frankly."

"In truth, sir, I should have liked to stay at home, to draw — these plants which we just now saw."

"Capital! that is well said. Stay at home, then: I will do my errand alone, and return to dinner. — Dame Orphise, please order the gray mare to be saddled: I will go alone."

M. Majorin kissed Jean, and went to his room.

Jean, it must be confessed, was somewhat heavy-hearted. To miss a pleasant trip, and the sight of his mother, brothers, and sisters, and simply to spend his time in drawing bits of plants, seemed to him, on reflection, rather hard; and he was about to seek his friend to declare that he had changed his mind. But he remembered that M. Majorin said to him one day, "When one has done a foolish thing, he should never be ashamed to confess it; it is the only way to make reparation: and when one has done his duty, what reason or conscience commands, it is folly to repent, even if only harm to one's self is the result."

Jean, therefore, subdued his grief, took his album, and

went straight to the end of the garden without turning his head. Involuntarily two or three big tears fell on his paper when he seated himself before some of the plants he wished to draw.

"Well," said M. Majorin to himself, looking from the window upon the child, who turned towards the trees, "the little fellow has something in view: it is well."

And, going down into the yard, he mounted the gray mare.

As Jean progressed in his work of copying plants, he felt a contentment he had never before known. These models seemed to him the more precious because he had sacrificed a great pleasure for them.

"Little plants," he said to them, "I love you very much, because I am going to remain with you, rather than to ride with my friend, and see my father and mother.

"Little plants, you must let me copy you, and help me make pretty drawings to please my friend."

And, when suddenly some opening of spring-blossoms made the grasses nod and quiver, it seemed to Jean as if the plants were answering him.

Then there appeared on the velvety blades a brilliant beetle, with long movable antennæ: it would pause a moment, as if to warm itself in the sun, then, opening its wings, would take its flight.

Jean tried to draw these insects, but they were too difficult: they posed so badly, and were so small.

Grave persons who are interested in the education of children provide them with little books, written for them, adapted to their understanding, and embellished with charming vignettes: they omit neither instruction in sound morals, nor the elements of the most useful knowledge. But a spring morning is often a much more fruitful source of education to these young minds. Place a child face to face with nature, and raise only a corner of the veil that covers her mysteries, and it will be the best way to develop his understanding, and to give him a desire to learn.

When Jean became a man, this day was never effaced from his memory; and he said, "It was then that I began to love nature, and since, my love of it has only increased. Who knows? perhaps, if I had gone with M. Majorin, I might have lost this opportunity. Would it ever have presented itself again? Great are the mysteries of the mind."

When M. Majorin returned to the factory at dusk, Jean was still contemplating the clusters of wake-robin. It seemed to him as if this day had been only an hour long.

During dinner he was silent, although his face expressed content.

"So," said M. Majorin at dessert, "you have been drawing in the garden all day. I will look at your work presently. Are you satisfied with what you have done?"

"Not very well, sir: it was quite difficult. And then

I had to get down on the ground to examine all the plants. Will you tell me their names?"

"Certainly: have you examined many?"

"Yes, a good many; some very small ones among the dead leaves, which took great pains to grow. I very carefully removed what was in their way."

"And did they thank you?"

Jean blushed slightly, and did not answer, not daring to confess his impressions of the morning, even to his friend; for it seemed to him as if it would have been profanation.

M. Majorin thought he understood him, and did not press the question, but asked to see the sketches.

They were all unfinished, but were tolerably rendered, and showed a nice observation and a purpose to analyze which did not escape the teacher.

Evidently the child had looked with the wish to understand and acquire. M. Majorin, taking the sketches, was explaining the successive developments of these plants, when a bat entered through the open window, and began to fly around the lamp. A whisk of a napkin brought it down to the table, and M. Majorin imprisoned the little animal under a tumbler. "Here," said he, "is a good opportunity to study a most interesting animal." Jean thought that this little, black, shapeless object, awkwardly jumping about under the tumbler, was very ugly and repulsive, and he would not willingly touch it with the tip of his finger.

M. Majorin went for a bottle of chloroform, and, saturating a corner of his handkerchief, passed it under the tumbler; and in a few moments the bat was powerless, ceased to move, and was soon dead. Then, while it was still warm, the teacher stretched it on a board, fastening its membranes with big pins.

The little black heap, which was only about seven centimetres long, measured, when stretched, out thirty-four centimetres from wing to wing.

"You have worked hard all day," said M. Majorin to Jean: "we will take a walk in the garden, and to-morrow evening we will look at the bat."

CHAPTER IX.

A LESSON IN COMPARATIVE ANATOMY.

WHEN the two friends were seated at the study table, M. Majorin, taking a volume prettily bound, and handing it to Jean, said, "Look, here is a book which will be the commencement of your library. It is called 'The Plant,' and is written by M. Ed. Greniard. You will find in it explanations of many of the mysteries into which you had a partial insight yesterday. So do not forget that a well-employed day is always productive: without counting what your own observations have taught you, the work which you have done affords me the opportunity to give you a book which will amuse and instruct you.

"Read it slowly, and, when a passage seems obscure, ask me to explain it.

"Now let us return to our bat of last evening. This animal, which generally causes aversion, — which, you will presently learn, is a most foolish prejudice, — is not

only harmless but useful, because it eats very troublesome insects, like gnats for example.

"It is a mammal, which means that it does not lay eggs like birds: it gives birth to young, which it nurses; and you will see that it has other points of resemblance to the human race.

"Come near it. Do not put on that look of disgust: leave such airs to young ladies who are ready to faint if a bat enters their chamber.

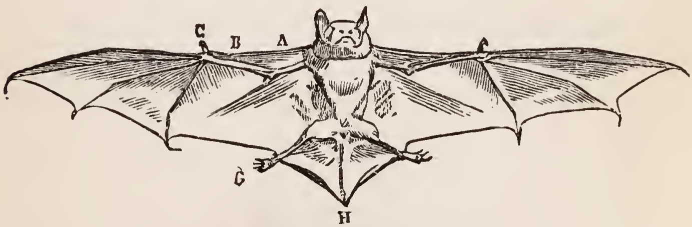


Fig. 50.—The Bat.

"I will tell you, by and by, how the head resembles that of a man. Let us first examine the limbs (Fig. 50). Suppose there is no membrane uniting them, and you see that the animal has arms and legs. These arms are fastened to the shoulders, like those of men, by triangular shoulder-blades, and are each composed of a bone called the *humerus* A, then of two bones, one of which is called the *ulna*, and the other the *radius* B. Take hold of your fore-arm, and you will feel these two bones which enable you to turn your hand.

"But the hand of the bat is longer than its arm: with the exception of the thumb, C, which is small, the fingers are disproportionately long.

"These thumbs have at their ends very strong claws, which allow the animal to suspend itself from the sides of walls, or from the trunks of old trees.

"The legs are comparatively short, but, like yours, are each formed of a bone called the *femur* (the thigh), which is attached to the pelvis, and of two bones called the *tibia* and *fibula*, at the end of which is the foot. You see at G the small feet of the animal provided with very sharp claws. The vertebral column (the backbone) is prolonged like a tail at H, as in all the mammals. This is called the coccyx; and man also possesses it, only it is hidden under the flesh.

"Feel of the animal's chest, and see how full it is; here are the powerful pectoral muscles which enable the bat to work its arms and very long fingers, which are united by a membrane attached also to the neck, legs, and tail.

"If the bat falls to the ground it cannot fly, because its legs have not the strength to give it the first impetus to make it rise. So it clings to some wall or branch with its thumbs or feet, and remains there in the daytime; when evening comes, it opens its arms, and drops, the membrane unfolding and forming a parachute; then, working its anterior limbs, it moves rapidly through the air without a sound from its velvety membranes. Of what a nice

material these membranes are made! and how pleasant it is to have so fine a cloak, so ample and pliant, and furred near the body, with which to wrap itself when it is still,

FIG. 51.—DETAILS OF THE BAT.

and with which, when unfolded, to fly through space as swiftly as an arrow!

"Now let us examine (Fig. 51) the arms and head of the bat.

"You see that from the neck, A, the membrane is attached to the base of the thumb of the hand, B, exactly as a cloak would be thrown over the shoulders, and which you would extend with your hands in opening your arms. This cloak is attached to the back and legs, and to the tail of the animal, which serves it as a rudder. Few animals are better provided for, and it is very wrong for people to despise it.

"Its head is quite as interesting.

"Its broad ears, whose membranes are fastened under the jaw, are wonderfully arranged to perceive the slightest sound, and also to protect the eyes at the side, which enables it to aim at its prey without being turned aside by oblique rays of light. Thus the eye of the bat easily perceives, in a demi-light, the tiniest insects that flit about in the evening, and owing to its rapidity of flight seizes them on the wing; for you see that it has a large mouth, with sound incisor and molar teeth like yours and mine.

"The bat, then, is not at all like a bird, but is a mammal which nurses its young: it has teeth and no bill; it has hands whose fingers are furnished with phalanges and nails, and it cannot walk or hop about like a bird; and if, through mischance, it happens to fall flat on the ground, it will with great difficulty, by painfully creeping along, seek a wall, a rock, or the trunk of a tree, to get a layer of air under it dense enough to enable it to extend its wings, and fly.

"Human beings have at times tried to make a flying-machine; but these fools (for one can hardly give them any other name) should first have observed the bat, which, of all winged animals, most resembles man. Now, in this country, a bat which from the head to the lower part of the loins measures six centimetres in length has a spread of wings of thirty-four to thirty-five centimetres, which is nearly six times the length of its body. The body of a man, from the head to the coccyx, measuring about a metre, the extent of its membranes should be six metres; and, to work such an apparatus, our weak lungs would not suffice, not to mention that at the end of our arms it would be necessary to add four fingers, from one metre fifty centimetres to two metres in length.

"You see that it is well to closely examine every work of creation, and that there is no good reason for regarding the bat as a repulsive animal to be despised. It is perfectly endowed, and was made rather to excite our admiration than our scorn.

"But here is something stranger still," said M. Majorin, as he took the following drawing from his portfolio (Fig. 52).

"This animal no longer exists on the surface of the globe; but it lived long before the appearance of man, and its skeleton is found in the rocks from which we take lithographic stone. It bears the name of pterodactyl, which signifies, very nearly, winged fingers. It

was a kind of flying or fluttering lizard (for it certainly could not make a long flight in the air by means of its membranes); it is not a bat nor a mammal, but a reptile, as is quite plainly indicated by the form of its head and its teeth, which are like those of the saurians.

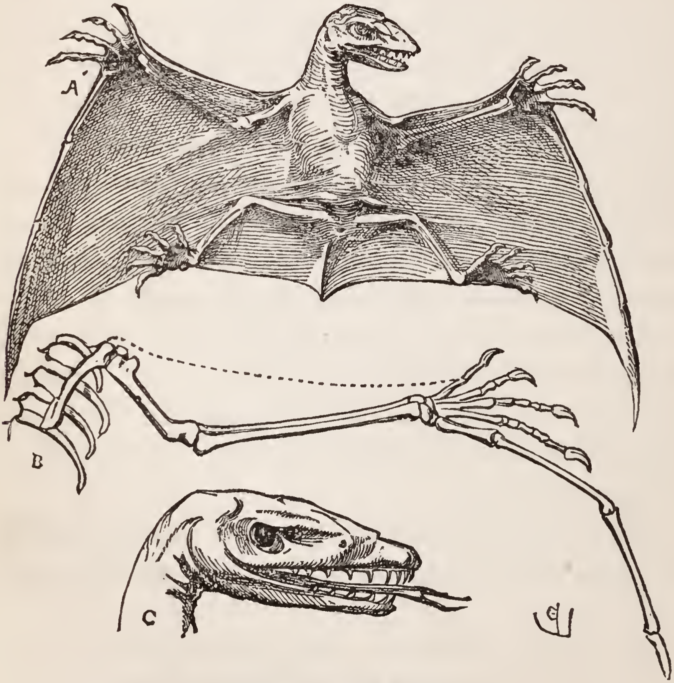


FIG. 52.—PTERODACTYL.

"This strange animal, which is hardly larger than a good-sized lizard, has arms, legs, feet, and hands like our own,

only the little finger is of extreme length, as you see at A; and serves to fasten the membrane which elsewhere covers the shoulders and joins the heels and the end of the tail. At B is represented this skeleton arm, of natural size, and at C the head of the pterodactyl with its muscles restored.

"The pterodactyl was not hairy like the bat, but had a wrinkled skin. On the whole, it was a rather ugly beast, which fed on insects, seized while it was on the wing. The sharp and spreading claws of the four fingers of the hand and of the five toes of the feet permitted it to cling to the sides of rocks, and to climb their perpendicular surfaces, like all lizards, but certainly with less grace and agility. Yet the form and size of the bones of the pelvis make one suppose that the pterodactyl could take a sitting position.

"You will ask me, perhaps, what is my purpose in telling you of strange animals. Simply this: that nature herself has sought and tried all forms. She takes time to accomplish her work, for nothing hurries her; but, having adopted a principle, she tries to secure every kind of result from it. Now, let us take your hand, for an example. Before succeeding in constructing the hand of man, that marvellous instrument, what attempts did she not make! The great saurians of the antediluvian period, found in the lias, rocks that were deposited thousands of centuries before the appearance of man, more or less resemble

the lizard and crocodile. Living in the water, they have, in the place of arms and legs, fins shaped like oars, which, moreover, have at their ends five united fingers covered with skin. Here is the *pterodactyl*, which has also five fingers; but one of them, the last, extends to an extreme length to serve as a muscle to the membrane that enables the animal to fly.

"Birds have their *humerus*, *ulna*, *radius*, and fingers covered by a membrane into which are fastened the principal feathers of the wings. The bat has a thumb to hang by, which takes the place of a hook; and the other four fingers reach a great length to serve as muscles joined to a membrane.

"Here is the horse, which walks on a single finger, of which the hoof is the nail; the four remaining fingers, which, however, are useless to him, are dwarfed, and concealed under the skin. The ox and goat walk on two fingers; but they have the three remaining ones, though they are concealed. The felines, like the tiger and cat, try to seize objects with four of their fingers, and succeed, owing to their nails which are movable. As for the thumb, it exists, but the animal is not able to make any practical use of it.

"The monkey begins to use its hand as we do; but the thumb is not directly opposite the four fingers, or is not present at all. Last of all, the human hand, which permits of your drawing, was fashioned.

"To obtain this superior form, it was simply necessary to extend the thumb, and to place it opposite the other fingers. How much time and effort, and how many different duties were required of these five fingers, before their best position was decided upon! These fingers, however, are always found, even when one or more of them is not used by the animal.

"It is rather absurd, you will admit, that one does not know how the tool necessary every instant to him is made. Man ought to know how his hand is constructed, not that it is in his power to change the instrument, but because, knowing it well, he may be able to use it to better advantage, and not to ask of it a service which it cannot render."

Taking the drawing of the skeleton of the right hand of a man (Fig. 53), M. Majorin continued thus: "This represents the back — as it is commonly called — of the hand, stripped of its skin, muscles, tendons, and ligaments. It is well, in the first place, that you should know the names of the different parts of this member. This union of little bones which you see at A is what is called the *carpus* (first and second rows); the long bones which come afterwards at B are those of the *metacarpus*, and form the thumb and the back of the hand, while the bones of the carpus compose the wrist. At C is the *thumb;* at D, the *forefinger;* at E, the *middle finger;* at F, the *ring-finger;* and at G, the *little finger*. Each of these fingers

has three phalanges, except the thumb, which has only two. At R is the *radius*, and at I the *ulna*, to which are fitted the bones of the carpus, disposed in such a manner

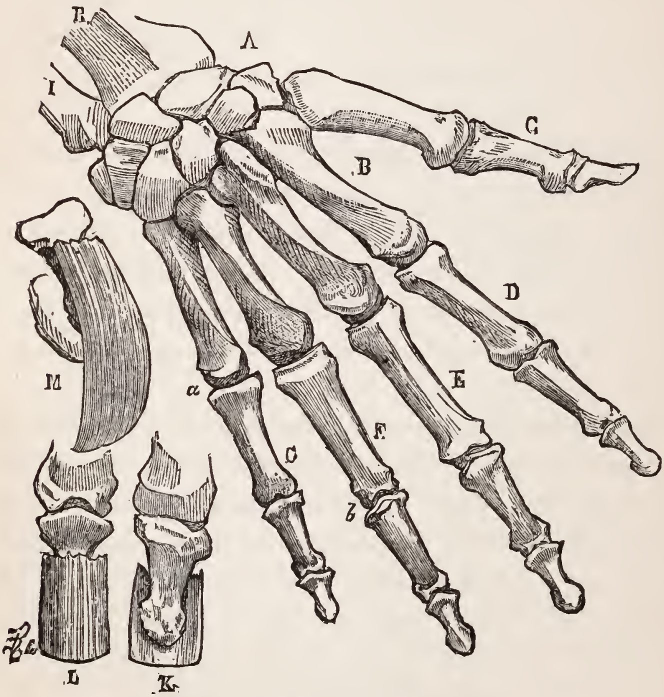


FIG. 53.—SKELETON OF A MAN'S HAND.

that the wrist can move in every direction, and turn half-way round upon itself, owing to the two bones R and I, which can pass over each other. You will observe that the first phalanges at their extremities are nearly flat, *a*,

and very slightly concave, while the heads of the bones of the metacarpus are rounded into half-spheres, which permits the fingers to move in every direction at their base, as you can prove.

"The articulation of the second phalanges with the first is different. The articulations are grooved; so that, while the fingers can bend forward and backward, they cannot be turned to the right and left. The last phalanges of the fingers, which bear the nails, end in the form of a spatula, as is shown in the sketch K (Fig. 53) which represents the back of one of these phalanges, of natural size, with the nail; and the sketch L gives the front of this same phalanx with its end concealed by the nail.

"But these nails are supposed to be trimmed, as is proper on civilized hands: when allowed to grow, they assume the shape indicated at M. This clearly is well designed, and serves to fasten together all these little bones without restricting their movements.

"I must first tell you that all these bones are covered with a very fine, fibrous envelope called the periosteum. Let us now examine how the bones of the hand are fastened in such a manner that all their movements are perfectly free (Fig. 54).

"We still present the back of the hand (posterior face). It is by the aid of fine, silky, pearly ligaments, which interlace, cross, and pass over each other, that the bones of the carpus are kept in place, and united together at A, and to the *radius* and *ulna*.

"The bones of the metacarpus and phalanges are in the same way united by lateral ligaments and by what is called the *transverse metacarpian* ligament, as at B; besides, extensor tendons follow longitudinally the back, and

FIG. 54.—THE HAND OF MAN, WITH ITS LIGAMENTS AND TENDONS.

flexor tendons follow longitudinally the front, of the fingers. These tendons are spanned by the transverse met-

acarpian. They are represented as cut after the union of the *metacarpus* with the first phalanges, to show the ligaments of the *carpus;* for they have just passed over these ligaments, and are retained at the wrist by a real bracelet made of a ligament. These posterior tendons (which are shown here) are called *extensors*, because they serve to open and lengthen the fingers; while the anterior, that is to say, those placed within the fingers, are called flexors, because they serve to close the fingers. At C you see the tendon (cut) of the *long abductor* of the thumb. You can feel it under the skin. This tendon plays an important part. It gives to the thumb its power to open wide, by means of which the human hand can seize very large objects. As for the *extensor* tendon of the thumb, it is cut at *d*, as its *flexor* tendon is cut at *e*, to show the lateral ligaments in the articulation of the two phalanges at *f*. At *g* is what is called the *hooked bone;* which is a little bone joined to the ligaments but not articulated, and which serves to give them more strength at the wrist, at the base of the metacarpal bone of the little finger. This bone is a great help when it is necessary to lift a heavy weight.

"In the same way there are little supplementary bones under the articulation of the thumb at *h*, called the sesamoidal bones, because they resemble a grain of sesame. They also serve as supplementary supports to the anterior flexor tendon of the thumb. You have noticed that the

thumb, short as it is, has great power of seizing. Well, these sesamoidal bones perform the office of giving more strength to the flexor tendon, so they are more developed in persons who are accustomed to severe toil, and do not exist at all in children, or always in women. They are formed beneath the tendons by age and exercise. I will spare you the names of all these ligaments: you will learn them later. I desire to show in a general manner how your hand is made, and how much time it has required for nature to perfect it; since, although so many animals already have five fingers, man alone can have full control of them."

During this lesson, which deeply interested Jean, he looked at his hand, and felt of it to try and find its bones and tendons; but it was not sufficiently developed for him to feel them all.

It was not so with M. Majorin's long, thin, and strong hand; therefore, resuming his lesson, he permitted his pupil to easily feel the bones and tendons which he had just described by faithfully copied drawings. And M. Majorin's large hand opened, closed, and extended itself so well that all its mechanism was plainly visible by the light of the lamp.

"But," ventured Jean, "who causes all this to move?"

"Ah, my lad, you are not weary of it!" resumed M. Majorin; "you wish to know who makes all this muscle

move, and where all the motive power is. The motor, or motive power, my dear, is your head, your brain. Your head is filled with a white and gray substance which extends along the vertebral column; and from that substance depart thousands of threads, like telegraph-wires, which are called nerves; and the mission of these nerves is to transmit your will to your limbs, which are provided with muscles, which can lengthen and shorten as if they were rubber fibres; and these strong muscles, with their tendons, instantly obey the order transmitted from your brain by the aid of all these nerves. Yet these nerves, which can receive impressions by touch, by cold, heat, hearing, and sight, transmit them to your brain. Thus you place your hand on a hot iron, and the nerves send a despatch to your brain to let it know that it burns; and your brain sends back a despatch to tell the nerves to command the muscles of the hand to make an immediate retreat. It is a well-performed telegraphic service; since not a hundredth part of a second passes between the impression received by the nerve, and the execution of the order given by your brain to avoid or to avert an accident. And, what is better, all these telegraphic services act in harmony. Your eye sees a ball coming towards you, and transmits the fact to your brain, which transmits to the nerves of your arm and hand the order to make the muscles act so that this hand will be held out to the wall to repel it to the right or left, or to seize it; which it does without hesitation.

"Your ear hears a voice which says, 'Forward, march!' It tells the news to your brain, which, without delay, sends to the nerves of your limbs the order for your muscles to act, which enables you to walk. This is not peculiar to man: animals, as well, have their nervous system and their nervous centre, which receives impressions, and transmits orders to the limbs.

"However, things are so arranged, that, although we have the control of our limbs to move them as we please, we cannot control our hearts to cause them to beat or stop beating, to arrest or start the circulation of the blood, to digest or not to digest our food. This is done in spite of ourselves, without our having to think about it, and in sleep as when we are awake.

"But it is time, Jean, to go to bed."

CHAPTER X.

SECOND LESSON IN COMPARATIVE ANATOMY.

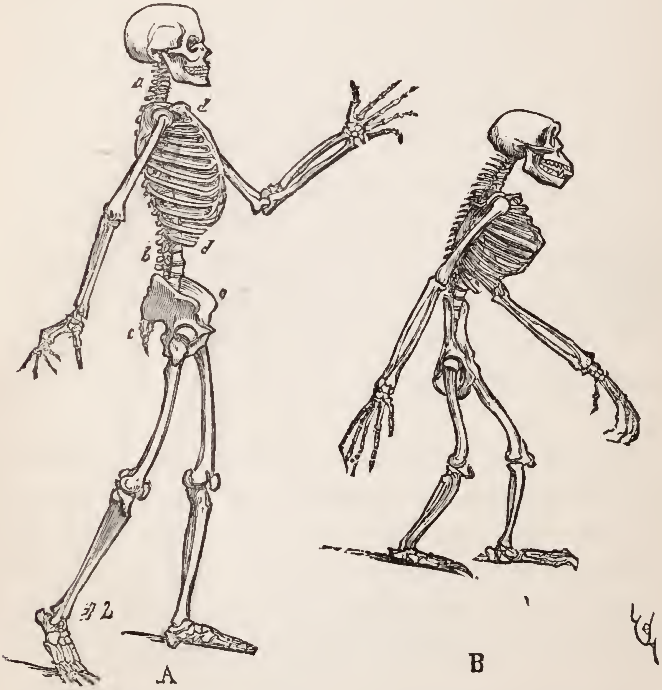
BUT M. Majorin did not limit himself to oral explanations, and exhibitions of models and drawings: he made Jean take notes, copy them plainly, and add sketches to them corrected by his teacher.

Jean did not remember technical terms; and M. Majorin was obliged to repeat them to him, and to make him write them opposite his sketches. Between these well-filled lessons he left an interval long enough for him to digest and assimilate them. He continued with these subjects for several days, and there were plenty of opportunities.

At table, after he had taken his first lesson in comparative anatomy, Jean attentively examined the chicken or rabbit bones, and M. Majorin profited by his pupil's examinations to review or extend his explanations. When he

could judge by Jean's remarks that the preceding lesson was well understood, he tried to advance.

M. Majorin possessed excellent anatomical studies taken from nature, and began his second lesson by placing



A B

FIG. 55.—SKELETON OF A MAN. SKELETON OF A CHIMPANZEE.

before Jean's eyes a drawing of life-size, representing a human skeleton in profile (Fig. 55) at A, and opposite a copy of a skeleton of a chimpanzee at B.

"Examine these two individuals attentively," he said. "Both have the same number of bones; and the difference between man and the chimpanzee, which is a monkey, consists only in the form and size of these bones. You will observe that the backbone of the chimpanzee is drawn in the line of a single curve, while that of man has the form of an S; that the arms of the chimpanzee are so long that he would run the risk, in ascending stairs, of walking on his hands; that the legs of the animal are short, and their bones are so curved that the legs cannot follow a straight line. Although the chimpanzee habitually stands erect, he has still preserved the habits of beasts which walk on all-fours: the standing attitude is a progression which has not yet attained its full development. The thumb of the hand is short, and is not of much use, not being wholly opposite the fingers.

"The bones of the pelvis are but slightly developed before and behind; the skull is comparatively small and retreating, and the jaw is very large.

"With man, the upright position has become habitual: his arms are well proportioned, his head is strong, and his skull is powerful.

"But I must tell you the name of the principal bones which compose the human skeleton. We will not stop to study the head, as we shall return to it presently. At *a* are the *cervical vertebræ;* at *b*, the five *lumbar* vertebræ; at *c*, the *sacrum,* or *coccyx;* from *d* to *d*, the twelve ribs; and at *e*, the bones of the pelvis, or hips.

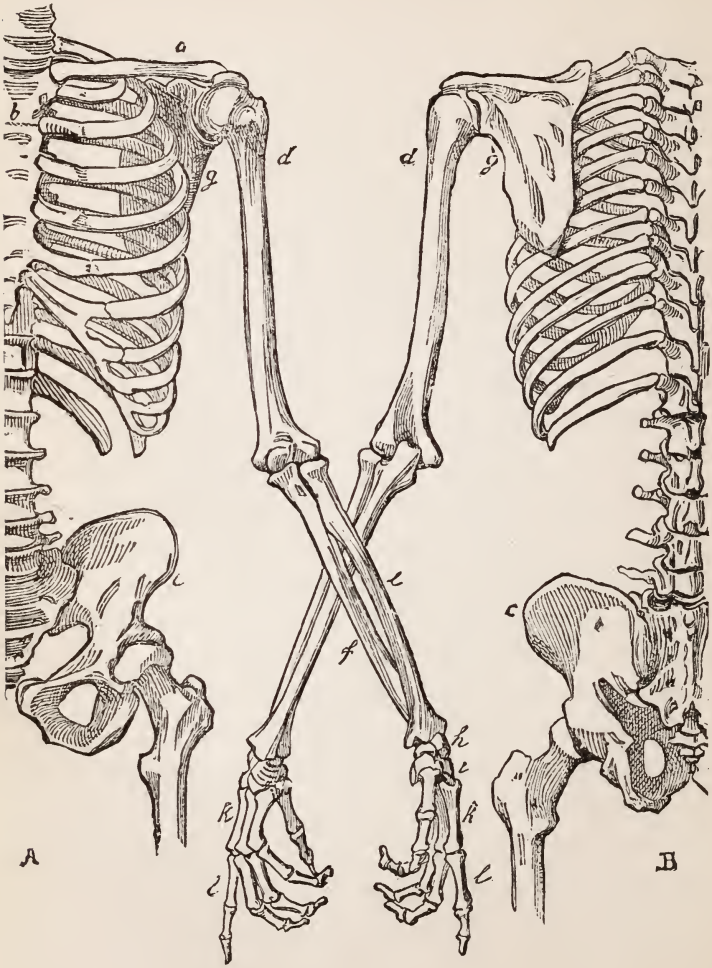


Fig. 56.—Skeleton of a Man, Anterior and Posterior Part.

"Let us look at the trunk of this person; A being the anterior, and B the posterior view (Fig. 56). At *a* are the *clavicles*, or collar-bones, which are very useful, as they enable one to open the arms; at *b* is the *sternum*, or breast-bone, a thick cartilage, to which are joined the ribs, excepting the last two, called the *false ribs;* at *c* is the bone of the hips, or pelvis; at *d*, the *humerus;* at *e*, the *radius;* at *f*, the *ulna;* at *g*, the *scapula*, or shoulder-blade; at *h*, the first row of the bones of the *carpus;* at *i*, the second row; at *k*, the bones of the metacarpus; and at *l*, the phalanges.

"Let us examine the limbs (Fig. 57). This at A is an anterior view, which faces us; while that at B is the posterior view. The big bone, *a*, is the *femur;* *b*, the *tibia;* *c*, the *fibula;* *d*, the *patella*, or knee-pan, a small bone in the form of a lens, which is unattached, and very necessary to permit the movement of the knee when one wishes to walk, and particularly when one ascends; *e*, the *astragalus*, or ankle-bone; *f*, the *scaphoid*, or boat-shaped bone; *g*, the *cuneiform*, or wedge-shaped bones; *h*, the *metatarsal* bones; *i*, the phalanges; *k*, the *calcaneum*, or the bone of the heel.

"You now know pretty well of what your frame, excepting the head, is composed; for it is a real frame, designed to receive muscles which put the mechanism in motion, and also nerves, whose mission, as I have told you, is to transmit your orders everywhere, and to make you feel sensations.

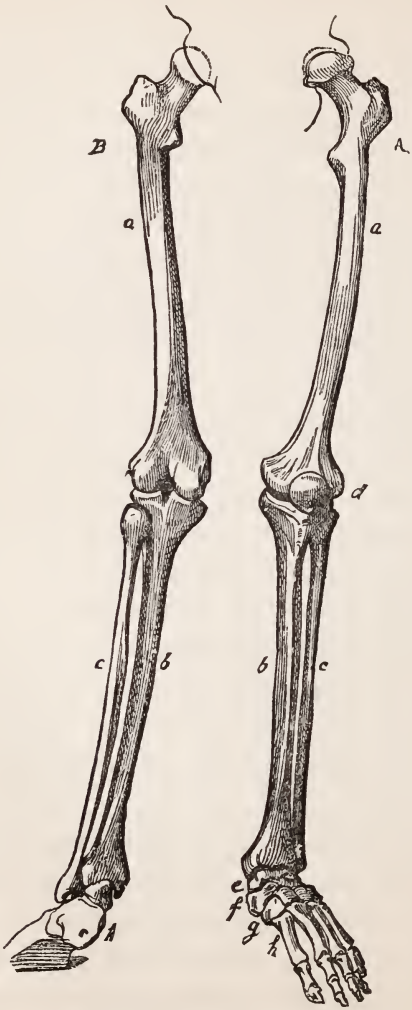


Fig. 57.—Bones of a Man's Leg.

"These drawings show you very nearly how these bones are united to permit motion.

"In all the parts in contact, and in the articulations, they are provided with a soft white substance, and are kept lubricated by a liquid called the synovial fluid, as the parts of machines which are in motion or rub against each other are oiled. These articulations are kept in place by supple ligaments, like those I showed you when we were studying the hand, to which are attached the tendons which end in the muscles, which are like so many bundles of fibres provided with the power of lengthening and shortening, and consequently of moving the frame at the joints.

"These muscles are preserved in good condition and nourished by the circulation of the blood, which, flowing through thousands of canals, carries health and activity everywhere and constantly until death.

"It is your blood, also, which makes your bones and muscles grow: therefore you must give it all it demands to fulfil its office, namely, air, food, labor, and rest.

"But behold how well made are these bones of the leg (Fig. 57) to carry the body. The *femur* is set in a cavity of the bone of the hips, which permits swaying from back to front, necessary in walking. The *femur* is bent to bring the weight of the body on the knee; then the *tibia* possesses a large head, provided with and strengthened by two cavities which receive the two rounded parts of the *femur* in order to insure the firmness

of the leg in a lateral direction. The connecting-rods of machines are always made in this way. The little bone called the *patella* is a lever to the muscles, and at the same time prevents the knee from bending from front to back. Then the *tibia* is straight, and placed edgewise in a manner to offer assistance in walking; and is aided by the *fibula*, which is a kind of support which prevents bending in a lateral direction. The base of the *tibia*, which is also broad, bears on an intermediary bone, the *astragalus*, which permits the movement of the foot; and this intermediary bone bears on a strong bone, the heel or *calcaneum*, which serves as a lever and wedge. The bones of the *metatarsus* are curved like an arch, in order that the leg, bearing on the heel, may find, at a distance in front, a support and wedge. Therefore man, of all animals, is the only one who walks upright; while monkeys, which stand on their lower limbs, have more or less the position given by Fig. 55, bent forward, and ready at need to make use of their long arms to prevent them from falling on their face.

"One should not be prouder on this account, however; for this wonderful human machine acts foolishly when the head which governs it is not well balanced, or has not fully developed its brain by a good education and a just appreciation of external objects.

"If his legs are fitly made to walk, the arms of man are just as fitly made to grasp any thing. The legs move

only in one direction, from front to back; and the foot can describe on the ground but little more than a right angle, unless the bone of the hips be turned. It is different with the arm, which moves in every direction, while the hand can turn almost entirely around on itself. It is owing to

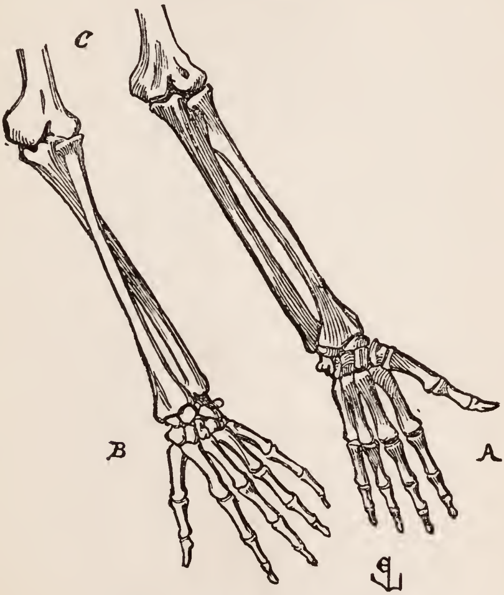


Fig. 58.—Bones of a Man's Arm.

the disposition of the *clavicle* and the *omoplate*, that the *humerus* moves in every direction; and to the disposition of the *radius* and the *ulna* that the hand can turn round. Indeed, these two bones, the *radius* and the *ulna*, pass one before the other revolving in the sockets of the *humerus*,

when you wish to turn your hand as is shown in Fig. 58. A is the inside of the left hand, and B is the outside; the *humerus* (C) remaining in the same position. This faculty, and the position of the thumb opposite the other four fingers, distinguish the human hand.

"When you have studied and understood these principles of anatomy, you will examine with more interest and knowledge the machinery of the factory; for man, in the art of mechanics, seldom does more than apply these elements.

"Having neither these supple and strong ligaments which fasten the articulations of the bones, nor the tendons and muscles, man replaces these beautiful inventions with bolts, axles, or pivots, and eccentrics; but generally the organic parts of his best machines are made in conformity to the principles by which his body moves.

"Here is a clear illustration (Fig. 59): at A, you see the lower end of the *femur*, and what is called the *condyli*, with the notch which separates them, and in which is fitted the projections of the *tibia*, *a*, and at *b* the concavities of the joint. The ligaments, which unite the two ends of the bones of the thigh and leg, and are attached to the sides, which are rough and pierced with little holes, permit the *condyli*, which are shaped like half-spheres, to turn in the two cavities, *b*. What does the mechanic do to secure a like result? He joins the two parts, like the head of a compass, so that they will turn in one direction but not in the other.

"He fashions the two pieces B and C, and unites them by a pivotal bolt: the head, *a′*, which replaces the projection of the *tibia*, fits in the groove *d;* the cheeks, *e*, turn

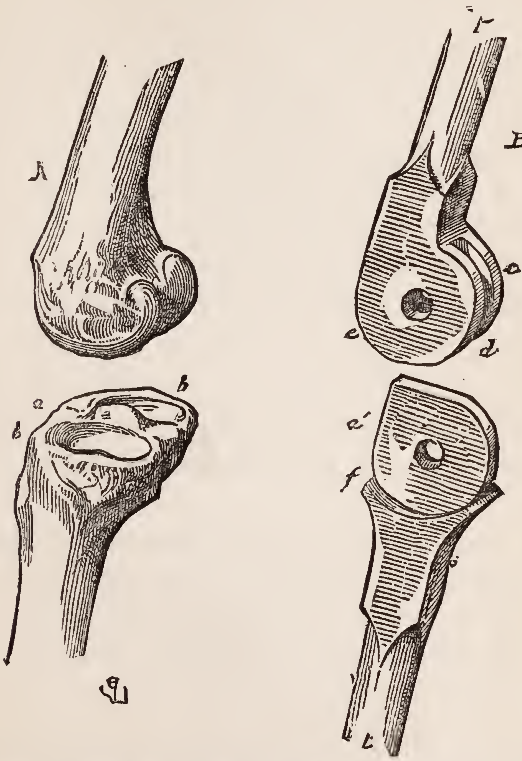


Fig 59.—Application of the Joints of the Bones to Mechanics.

on the rest *f*, and the round shafts, like the bones, are strengthened at the joints.

"However, between the animal machine and those which

we manufacture there is a great difference. We can, more or less perfectly, construct the parts of our machines in imitation of bones, tendons, and muscles; but to all of them it is necessary to communicate motion by an independent force, — by water, air, or vapor, or by a horse, which are called motive powers. The animal machine has no need to be urged by a power independent of itself: it bears its motor in each of its organs. The discovery of a substance, or a combination of elements, which possessed the power that the muscles and tendons have of lengthening or shortening would be a very valuable one, for it would do away with many parts of very complicated machines; but we have none such, and we must, for the present, content ourselves with studying animal mechanism, and with borrowing from it all we can, that is to say, the principles applicable to the subject.

"I will show you, for example, how certain animal forms can be applied to mechanism. Here (at Fig. 60) is the hind-leg of a stag or a reindeer, or that of an elk or a large antediluvian stag; the arrangement of the bones of these swift animals being nearly the same, their lower limbs have so much elasticity that they leap over large obstacles. The *femur*, *a*, is short and very strong; the *tibia* *b*, in addition, is very powerful at the upper end, and has great freedom of action.

"But this is the *calcaneum*, *c*, the heel, which with us

hardly extends beyond the union of the tibia and the fibula, and which here projects a good deal. Then come the bones, the *astragalus*, the *cuboidal*, &c., *d;* then the bones of the *metatarsus*, *e*, which are very long, while correspondingly short in the human foot; then, last, the *phalanges f*, only two of which aid in walking.

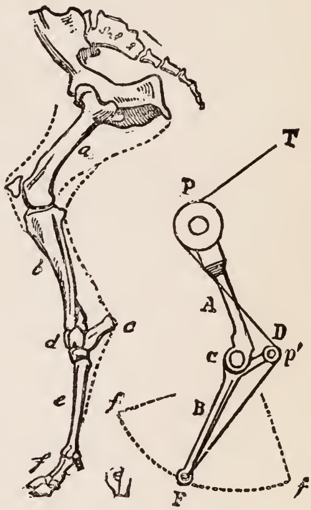


FIG. 60.—APPLICATION OF THE PLAY OF MUSCLES AND TENDONS TO MECHANICS.

"Why is this calcaneum so prominent? To act as a lever to the tendons and muscles, whose duty it is to move the limb.

"Suppose we wish to construct, by an analogous process, a piece of machinery with a capacity for quick and powerful tension: we should have in A a shaft provided with a pulley, P, at its head; a second shaft, B, with a joint, C, and a projection, D, bearing also a pulley, *p*, at its end. By fastening a cord to a fixed point at F, and passing it along the grooves of the two pulleys, *p'* and P, and drawing it quickly at T, we give a sudden tension to the two shafts, which move to a straight line as at P *f;* since, drawing the cord at its end T, we have shortened the irregular line, P *p'* F.

If the point f were placed at f', which the animal can do without difficulty, by drawing the cord, we should suddenly have described at this point f', the quarter of the circle f' f, and have thus caused a very quick forward movement from the point P, supposing this point f' to rest on the ground.

"With us it would be necessary to draw a cord at T to set the mechanism of our limb in motion. It is the tendons of the animal himself, which, having the power to contract or to extend at will, produce the effect caused by our cord, and permit him not only to make the movement we have just given to our piece of mechanism, but to return the limb to its first position, which we could do only by means of another process than that indicated in our figure. You see that while the calcaneum is useful to us in walking, and permits us to run, dance, and skip rope, being developed quite differently in the stag, it helps him to leap ditches and every obstacle met with in the forests.

"If ever you are a machinist, remember that to manufacture the parts of these machines, it will be useful to have some anatomical knowledge, and to know how bones are made, why they are strengthened at a certain point, and why they have taken a certain curvature.

"One could write a treatise on mechanics, having for his sole subject the curvature of the bones. But, if it is necessary to study at least the elements of comparative anatomy, one must draw a great deal to engrave on the

mind the forms so suited to their purpose, the service required by the animal.

"But while we are studying the muscles of animals, including man, the head of the latter is worthy of our examination."

M. Majorin then went to a closet for a human skull, which he placed on the table, and began to describe its various parts to Jean. At first its appearance (for it was yellow with time) caused him an unpleasant feeling; but soon M. Majorin's explanations interested him so much that he thought of nothing but of hearing him.

"This bony case," said M. Majorin, "is only a single piece, yet is composed of at least seven principal parts, without counting those that are accessory, or the lower jaw; and you will observe how they are fitted together by very delicately jointed sutures.

"These are the names of the principal pieces: the bone of the forehead is called the frontal; the two at each side, the temporal; there are the cheek-bones; the upper and lower maxillary, or the two jaw-bones; the bones of the nose; the occipital, or the bones of the back part of the skull; and the parietal, or the bones of the side and upper part of the skull. Before speaking briefly about the principal part of the head, — the skull, which holds the brain, — let us first examine an important part, the jaw, which enables one to chew, and to send food to the stomach properly masticated. You know that your

upper and lower maxillary are furnished with teeth above and below, — the eight incisors, the four canines, the eight little molars, and the twelve large molars, numbering in all thirty-two. There are four more large molars, which are back teeth, and called wisdom-teeth because they rarely appear until from the eighteenth to the twenty-fifth year, but which, however, do not always prove that those who have them are very wise. The four canines are modified forms of those terrible tusks which belong to the carnivorous animals, — the wolves, hyenas, tigers, dogs, and, &c. With the eight front teeth and the canines, prey is seized, cut, and torn to pieces; when it is thus prepared, it is sent to the molars to be ground into paste, in order that it may be easily swallowed, and when mixed with the saliva be digested. You have read 'The Story of a Mouthful of Bread,' by M. Macé, so I need not talk further on this subject.

"In civilized man, the canines are with difficulty distinguished from the incisors: they are only a little sharper and stronger; but in savages, and above all in those who readily eat raw meat and sometimes their fellow-beings, they are larger. With the chimpanzee, for example (Fig. 55), these canines are tolerably well developed: in the same way, also, the jaw is more retreating and weaker in civilized than in savage races; but, as a compensation, the skull, which contains the brain, is more developed in ourselves than in savages.

"The lower jaw of carnivorous animals, especially that of man, presents a curious peculiarity.

"You see how the pivots which are called the condyli, on which turns the lower maxillary bone, permit the jaw to open and shut; at the side, the zygomatic articulation, placed beneath the cavity of the temporal bone, is attached by a powerful muscle, lodged in that cavity, called the temporal fossa. It is by the aid of this muscle that the jaw continues the motion which grinds the food; though the *condyli*, the pivots of the jaw, are lively enough in their sockets for the lower maxillary bone to move very decidedly to the right and left, which allows the *molars* to masticate food.

"This motion is peculiar to all carnivorous beings, but in greater perfection in man; while, on the contrary, in reptiles, which have only conical teeth and no molars, the lower maxillary bone can produce only a motion like that of a hinge. These animals cannot chew their food, but snap it up, press it flat, and pierce it with their teeth, and are obliged to swallow it imperfectly masticated.

"The human jaw is, then, very perfect. The skull is equally so. Compared to its height, it presents a breadth noticeably larger than that of other carnivorous animals; and the *frontal bone*, instead of retreating and being depressed where it leaves the arches of the eyebrows, as in carnivorous animals and even in monkeys, rises almost perpendicularly. So one can learn, to a certain degree,

the intellectual qualities of a man by the elevation of this frontal bone.

"Man classified scientifically is only a mammal; but his intellectual faculties, owing to his build and the size of his brain, place him far above all the animals of the earth.

"He alone possesses the power of speech to communicate his thoughts; and he alone is capable of perfection: for he does not build his houses to-day as were built those of his ancestors, who lived in huts or caves; he accumulates, by the aid of writing, all the knowledge acquired by preceding generations. The most intelligent animals do not change their habits unless they come into contact with man, and are qualified to become his servants. The swallows build their nests to-day, the beavers erect their huts, and the rabbits dig their burrows, as in the time of the Pharaohs.

"The monkeys, which most resemble men in their form, like the gorilla and the chimpanzee, seem to have changed their habits very little since they were first known. The human brain, the seat of intelligence, sensations, desires, memory, and foresight, is therefore, thus far, the most perfect created thing; but it must be added that it took a great deal of time to contrive this human head which tries to discover the mysteries which envelop its perpetual toil.

"Ought man to feel vain because of this superiority, and think himself, as is sometimes declared, the king of

nature? Alas! no; for the more he develops his intelligence by the observation of the phenomena passing before his eyes, the more he penetrates the secrets of nature, the more he is led to confess his powerlessness to discover the laws of universal order.

"In extending the field of his knowledge, he sees the limits widen. That is why the true *savants*, who have penetrated as far as possible in the domain of observation, say, 'What I think I know, is, to what I do not know, as a grain of sand is to the seashore.'

"But is not the knowledge of one's powerlessness the mark of human genius? When he confesses his ignorance, it is because he knows that beyond his limited knowledge are endless mysteries which he can never fathom."

CHAPTER XI.

MENSURATION AND SURVEYING.

ONE Thursday afternoon the two friends, provided with two double-metres, one of which was furnished with a spirit level and a plumb-line, set out for Bièvre. The trees were beginning to turn green, and yet through their tender foliage could still be seen all the branches blushing with new sap.

Not a breath of air stirred the growing grass, and the country seemed to pause and meditate over its spring work.

"It is fine weather to make elementary experiments," said M. Majorin, when they reached the water's edge. "Do you know the width of this river at this point?" he continued.

"No, sir."

"But what do you think it is?"

"It may be six metres wide."

"Would you like to know exactly, within a few centimetres, and without fording the river?"

"How?"

"Suppose you are in the country, and that this stream of water is too deep to risk crossing it, and yet you must bridge it in order to reach the opposite bank: how would you ascertain the width of the river at a given point?"

"I do not know."

"You will see that it is not a difficult problem. Here is a little strip of sand, almost on a level with the water. Stand one of the double-metres close to the edge there, and have it perfectly perpendicular by aid of this plumb-line. Good. Now measure four metres backwards, and stand in the same way the second double-metre, which has a sliding gauge (Fig. 61).

"That is right. Move the level to the height of your eye, and, when the bubble of air is at the centre of the tube, sight the other metre. Do you see the point sighted?"

"Yes: it is the number 1 metre 80 centimetres (*b*)."

"See how much of this double-metre is in the ground."

"20 centimetres."

"Then, there remains, between the ground and the point sighted, 1 metre 60 centimetres, does there not?"

"Yes, sir."

"You must then turn round to the second double-

metre, and, from the point where the gauge is placed, sight an object on the other shore, — a pebble, a stake, no matter what, — a little above the level of the water. Do you see any thing?"

"Yes, a little white stone."

"Well, in sighting the top of this little white stone, which indeed is very nearly on a level with our strip of sand, where does this top touch the first double-metre?"

"At the number 1 metre 50 centimetres."

"Then, between your first point, *b*, and this at *c*, there are 30 centimetres; and between this point, *c*, and the ground there is 1 metre 30 centimetres, because 20 centimetres are in the ground. Am I not correct? Let us draw it on a piece of paper.

"Here are the two stakes, the point *a* which is the height of your eye, the line *a b* which is horizontal, and consequently perpendicular to the line *b d*, which is vertical, and the point *c*, the intersection of the pebble sighted with this first stake *b d*. Then you have a triangle *a b c*, one side of which, *a b*, is two metres, and the base, *b c*, 30 centimetres; then another triangle, *c d e*, similar to the triangle *a b c*. You know that this base *c d* has 1 metre 30 centimetres: therefore, the triangles being equal, the side *d e* is to the base *c d*, as the side *a b* is to the base *b c*. You have only to apply a rule of proportion, and you will know the length of the side *d e*, the width of the river. 30 centimetres are to 2 metres,

as 1 metre 30 centimetres are to 8 metres 56 centimetres. (I omit the fractions.) Therefore the river is 8 metres 50 and a fraction centimetres in width, and you can build your bridge with safety. Come and perform the experiment alone at another place."

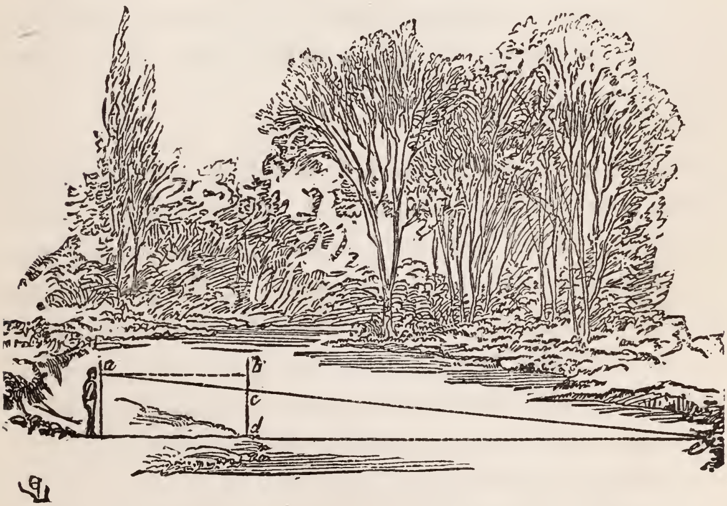


Fig. 61.—First Lesson in Mensuration.

Jean repeated it without his teacher's help, and finished with honor, which made him very proud.

After this first experiment, the two friends were approaching Frène, when M. Majorin saw a sign-post at the intersection of three roads.

"Well, my lad," he said, "do you know what is the height of this post?"

Jean attempted to measure it with his double-metre, but he could not reach the top.

"Good!" continued M. Majorin: "you will not succeed; but we can find this height without a measure. Suppose that this sign-post is three times longer. Look! you see yonder, at some distance, a small pool of water. Measure the distance between the post and the centre of it: what is it?"

"Seven metres."

"Mark the point by carefully standing a twig of wood in the water, without disturbing it. That is right. Now retreat on the line you have just drawn, until you see the top of the post reflected in the water, at the point where your little stick is. Can you see it? Then stand very erect, place this double-metre in front, close to your chest, draw your foot on the gravel, and mark the point on a level with your eye: what is your height?"

"1 metre 25 centimetres."

"How far is it from the perpendicular falling from your eye to the ground, to the little stake in the pool of water?"

"1 metre 75 centimetres."

"Well, (Fig. 62) you have now the height of the post. The reflection in the water at *c* makes an angle of incidence, which gives with the horizontal *a e* two equal

angles, *b c a*, *d c e;* you have the height *a b*, the base *a c*, then the base *c e;* the two triangles *b a c*, *d e c*, being equal, the base *a c* is to the side *a b* what the base *e c* is to the side *e d*.

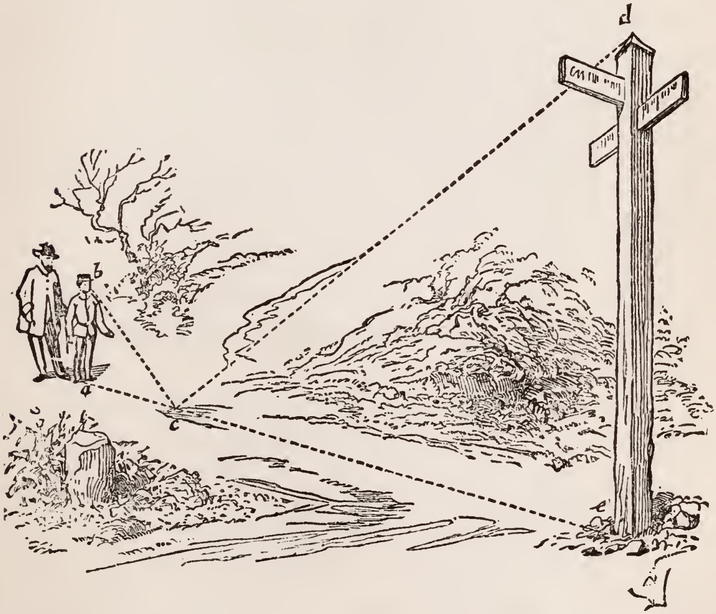


FIG. 62. — SECOND LESSON IN MENSURATION.

"Now, 1 metre 75 centimetres are to 1 metre 25 centimetres as seven to five. The distance from the point *c* to the post being seven metres, as you said, the post is five metres in height. Is this perfectly clear to you?"

"I think so, sir."

"Then explain the experiment to me."

Jean this time did very well.

Soon M. Majorin reached an old abandoned well at some distance from the road.

"Ah!" said he, "chance serves us well to-day. You now know one of the ways of measuring the height of a post, a column, or a tree; because, for lack of a pool of water, you can place a mirror or a pail of water on the ground, which will give you the desired angle of incidence. What would you do to ascertain the depth of a well, from the top to the surface of the water?"

After reflecting a moment, Jean said, —

"I should fasten a pebble to a string, and let it slip down to the water; then, drawing up the string, I should measure it."

"Yes, that is one way; but if you have no string, and only these two metres, what would you do? Do you not know? Well, this is one way. (Fig. 63.) Place one of these metres across the top of the well, and, in propoition to the diameter of the circle, let fall the second metre down the well along its perpendicular wall; keep the metre firm, and bring your eye to its top, and sight the opposite edge of the water. If you do not see it plainly, throw into the water a small pebble, and it will make circles, which, growing larger and larger, will vanish against the wall of the well, making a bright line at the

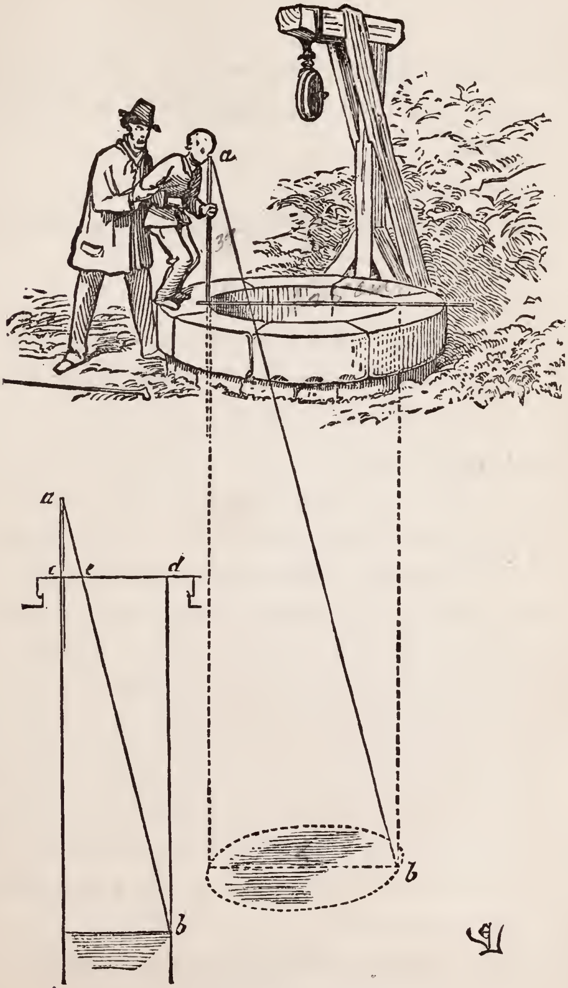


Fig. 63.—Third Lesson in Mensuration.

meeting of the water with the wall. Have you done so?"

"Yes, sir."

"Well, look at the point on the horizontal metre intersected by this line from the edge of the water, and tell me the number."

"30 centimetres."

"But, as 5 centimetres of your metre rests on the curbstone, it is only 25?"

"Yes, sir."

"The experiment is finished, and this sketch will explain it to you. At *b* is the level of the sheet of water; *c d*, the interior diameter of the well, which is about 1 metre 40 centimetres; *a c*, the perpendicular metre, which is a metre, and the base *c e*, which is 25 centimetres; which shows that from *e* to *d* there remains 1 metre 15 centimetres. Therefore, according to the principle just applied at the edge of the water, we say: the two triangles *a c e*, *b d e*, being equal, the base *c e* is to the side *a c* what the base *d e* is to the side *d b*; therefore, since you know the lengths *c e*, *a c*, and *e d*, you have the depth of the well to the water, which depth is the length of the line *d b*: 25 centimetres are to a metre as 1 metre 15 centimetres are to 4 metres 60 centimetres. Therefore from the top to the surface of the water, there are 4 metres 60 centimetres."

While walking, they conversed on this subject.

"Then," said Jean, "when one wishes to learn the height of a mountain, or the depth of a very deep hole, are these the ways to find it?"

"My lad, the ways I have just shown you are entirely primitive and elementary, and not sufficiently exact to permit of general use. To work accurately, one has instruments whose use I will explain a little later. As to the height of mountains, since it is very difficult to find the true point on which would fall a vertical lowered from the top to a horizontal plane passing through the point of observation, and consequently through the base of the triangle, which would permit one to know very exactly the distance that separates the operator from the horizontal projection of the summit, one only approximately knows the perpendicular side of this triangle, and the height of the mountain, and the experiments cannot be absolutely correct.

"In other words (Fig. 64), if you are at *a*, as I show you, and have before you the top *s*, to learn exactly its height in relation to the horizontal plane *a c* on which you stand, you would first need to know very exactly the distance from your eye to this point *c*, the horizontal projection of the point *s*; then, by the aid of a quarter of the graduated circle, you should take the angle *e f*, and then the hypothenuse *a s* would give you the exact height *s c*. But again, the difficulty is to exactly measure the length *a c* on a horizontal plane which does not exist, since to meas-

ure it with rules, it would be necessary to cut a tunnel on a level from *a* to *c*, and a well vertically at *s c*.

"To measure the height of mountains, a more correct method is followed by using the barometer. The air being lighter as one rises, the mercury is less charged, and descends in the tube, thus indicating by its fall the height which one has reached. But an observation with

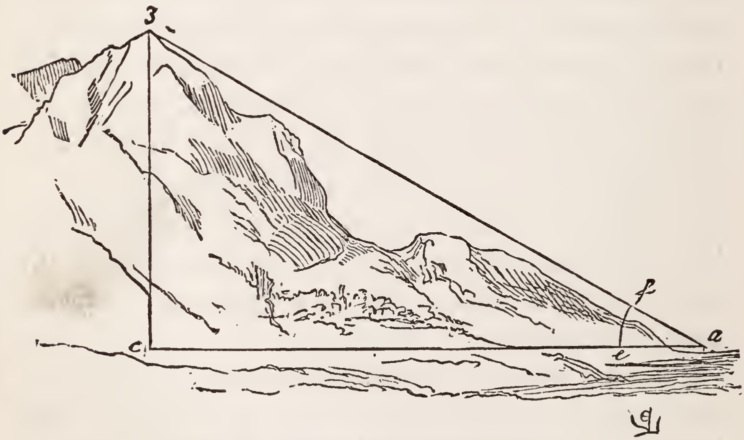


FIG. 64.—MEANS OF MEASURING HEIGHTS.

the barometer should be made at the same hour at the point from which one starts, for you know that the column of mercury varies continually as the atmosphere exercises a varying pressure upon it. Comparing the two simultaneous observations, and keeping account of the temperature, the greatest exactness is reached. But you must repeat these observations, and find the average."

"You showed me, sir, how maps can be made by means of triangles when one has measured a base; but how can mountains be marked out on a map?"

"Every topographical survey consists in first marking all the points which it is necessary to describe, on a plane, as if they rested on a horizontal surface; and this is the horizontal projection of all those points, whatever their altitude."

"But if a mountain is very high?"

"From your remark, I know that you do not quite understand this imaginary horizontal projection, and are not yet familiar with matters relating to projections and planes in space. I do not reproach you, for time is required for these experiments to impress themselves upon your mind. But let us sit down in view of this landscape, and I will explain every thing. (Fig. 65.) Here at A is our graduated circle, whose use I have explained to you; and at B is the tree, which is a little to our right, far above our point of observation, At C, on our left, is a small house a little higher than we are; and behind us is the boundary D along the hollow below our level.

"Suppose that through this point A, which is our graduated circle, there passes a horizontal plane in front of us: it will cut the base of the hill, and behind us it will pass far above the hollow. Do you perfectly understand?"

"Yes, sir."

"Now, through the points A and B we pass a vertical

plane, which I mark. It will cut the tree and all the ground between it and ourselves, just as I draw it, and it

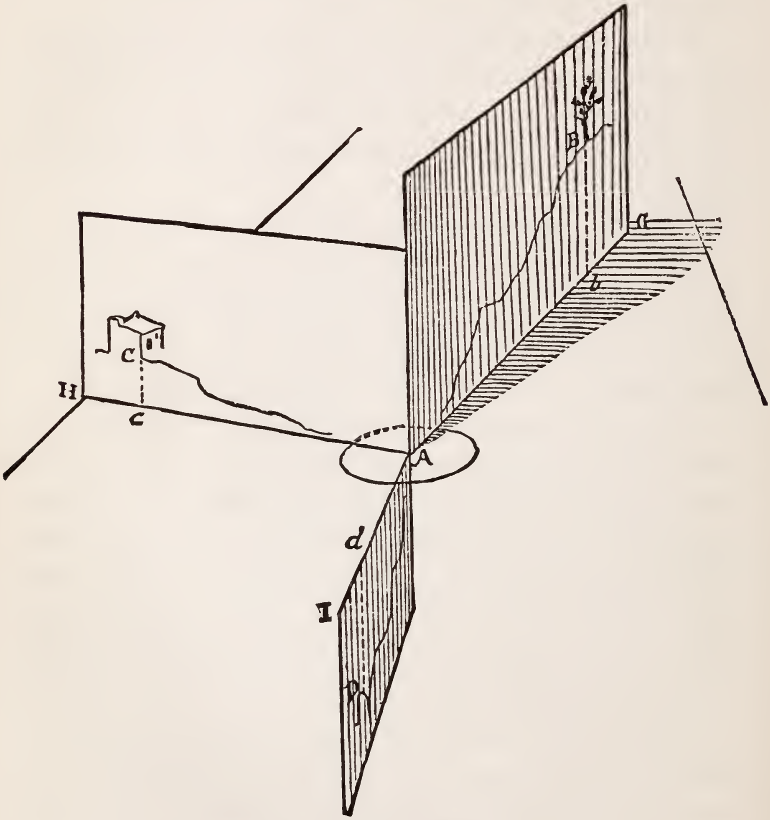


FIG. 65.—TRIGONOMETRY.

will then cut our circle and the horizontal plane along the line A G.

"Let us proceed similarly with the house C: we shall have a second vertical plane, whose trace on a horizontal plane will give with the first a certain angle on our graduated circle. With the boundary we do the same; only, the vertical plane which will pass through the centre of our circle and this point D will be beneath, and not above, our horizontal plane. Its trace A I, on this horizontal plane, will form, with the lines A G and A H, two other certain angles on our graduated circle. Do you understand?"

"Yes, sir."

"Well, let us bring down the points B C D on this horizontal plane by verticals, and we shall have the points *b c d*, the horizontal projections of the tree, the house, and the boundary, exactly at their plane, notwithstanding they are above or below the level of our circle. Then, if we wish to indicate on our maps the level of each of these points above a horizontal plane, to enable men in all countries to read them, we take by agreement the sea for the horizontal plane.

"We suppose a succession of parallel horizontal planes which consequently are equidistant from each other, either five, ten, twenty, or a larger number of metres. These horizontal planes cut the ground; and the line where they cut it is marked, which gives to the whole length of the slice the same altitude. These are called horizontal curves."

"I have not seen them on the maps at school."

"At school they give you maps designed in particular to fix in your memory the boundaries of continents and states, the course of rivers, the situation of towns, and of chains or groups of mountains, and the route of great highways: but these maps are on so small a scale that it is impossible to draw the curves indicating equal altitudes; for, what is the height of the highest mountain in Europe, — Mont Blanc, for example? 4,880 metres, or not quite five kilometres. This is very little compared to the surface of continents; and on a map of France, which is about 900 kilometres from Dunkerque to Marseilles, as a bird flies, you can imagine what represents this altitude of 4,880 metres, — a slight wrinkle.

"These horizontal curves are therefore only applicable to maps drawn on a large scale, that of the fifty thousandth, for example, or, if you prefer, maps that are fifty thousand times smaller than the country represented.

"To return to the horizontal curves: suppose that you have before you a hill which you can cut into horizontal layers, each ten metres thick, as the sketch shows you, at A (Fig. 66). The layers will be marked by the points *a*, *b*, *c*, *d*, *e*, *f*, &c.

"It is understood that one always starts from the level of the sea, N O. The foot of the hill, whence we make the first layer, *a*, is twenty metres; the second, *b*, thirty metres; the third, *c*, forty metres, &c., — above this level

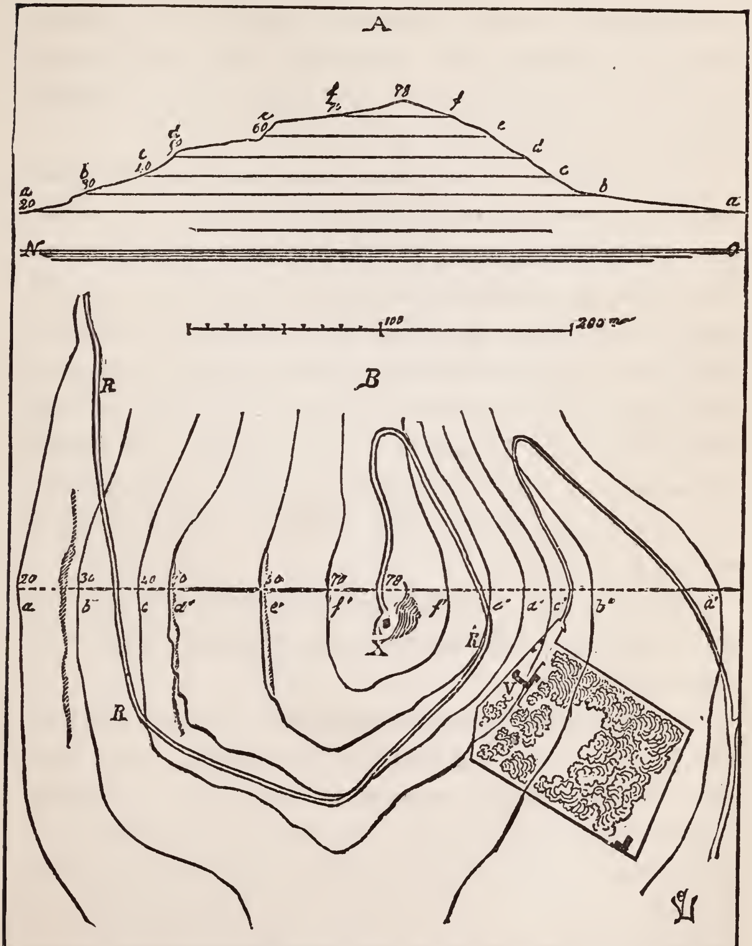


FIG. 66.—HORIZONTAL CURVES.

N O. But, instead of looking at this hill vertically, let us consider it on the horizontal plane B. Our section being represented by the dotted line, the layers are represented by the curves, a', b', c', d', e', f', and the altitude of each is given in numbers.

"If we examine a map thus drawn, we have the exact local configuration, not only in the matter of distances, but also in the matter of relative altitudes. Thus we know that the château V at number forty is thirty-eight metres lower than the tower X at number seventy-eight. We know that if we wish to ascend by the route R to the summit X, on which this tower is built, we will find inclinations of about ten centimetres to a metre; since between one horizontal curve and the other, according to the scale of our map, we have about a hundred metres to traverse.

"When you are a soldier, and serve in the artillery or as an engineer, you will know the importance of maps with horizontal curves.

"On old maps, there were sometimes numbers marking the height. Here, for example, there would have been the numbers twenty metres at the foot of the hill, seventy-eight metres at the top, and the indication of a road; but how can it be ascertained whether this route, in order to rise to this altitude of fifty-eight metres, is drawn as a regular incline, and whether at certain points it does not give an incline too steep for heavy wagons?

"With horizontal curves this uncertainty can no longer exist; and, from the way a road is represented as bearing on these curves, one knows that it gives such or such an incline. If your commander should order you to bring a battery to the point X, by examining the map with its horizontal curves you would find that it could be done without difficulty, since you have to ascend an incline of only ten centimetres a metre during a course of about six hundred and fifty metres."

As the two friends were sitting near an open pit, they discovered a pile of damp sand left there by the wagoners. Jean then tried to draw with a little stick the horizontal lines along this pile; but he did not succeed, and the lines were irregular.

Then M. Majorin, taking the double-metre, fastened to it with the end of a string, a stick, ten centimetres from its end and at a right angle; then, having lightly levelled the earth around the pile of sand outside, by turning the rule vertically around it, he showed Jean how the point of the stick, extended like an arm, marked a horizontal line of ten centimetres on this pile above the levelled earth.

This first horizontal layer being marked, the cross-piece was fastened at twenty centimetres from the lower end of the rule, and the second layer was obtained, and so on to the top of the pile.

This experiment at length made Jean understand the

manner of obtaining horizontal curves on ground that was more or less inclined. But, as one cannot walk with a rule a hundred metres high around Montmartre, and find a level path at the foot of the hill, M. Majorin explained to Jean how the same result was obtained with a theodolite, and promised to teach him how to use this instrument.

The occupation in which teacher and pupil were engaged seemed to greatly puzzle a man who was passing with a boy. Both stopped at a distance, and with gaping mouths watched the *bourgeois* and his little companion carefully drawing horizontal lines around a pile of sand. When it was done, the peasant approached and examined it. Seeing his perplexed look, M. Majorin said to him quietly, —

"My worthy man, what we are doing seems to surprise you. I am teaching this boy to make ground-levels. Do not feel anxious if this heap belongs to you, for we do not wish to do harm to this half a cubic metre of sand."

"No need of apology, sir. Don't disturb yourself: I know very well that you have no evil intent," said the peasant, walking round and round the heap with his hands behind him.

"Come," said M. Majorin, "explain to the gentleman and to this little fellow what we have just been doing."

Jean blushed to his eyes, scratched his head, looked at M. Majorin, the rules, and the sand-heap, but did not begin.

"Come, come," repeated M. Majorin: "if you have clearly understood it (as you must have done), you ought to be able to explain it."

Fig. 67. — Practical Lesson.

When his first feeling of embarrassment was overcome, Jean did pretty well; and when the illustration was over the peasant said, —

"Bless me! children learn wonderful things nowadays; it was not so in my time: we know nothing about any thing, but these children will know every thing. Excuse me, sir, for having interrupted you. If you would like to stop and have a bit of refreshment, I live only thirty steps from here; and, besides, the child must be thirsty after talking like a professor."

"We will go to your house with pleasure, my dear sir; and drink to your health, and to the success of schools. Does this little boy go to school?"

"Yes, sir; but he is rather young; he is my grandson."

"And he likes to take walks with grandpa?"

"Oh, yes! when his parents are in the fields, and there is no school, he comes to grandpa's. But I can't teach him any thing," added the good man with a sigh.

They soon reached the house, and the old man went to his cellar for a bottle of wine.

After M. Majorin and Jean took leave of their host, promising to return, the former could not refrain from expressing his thoughts aloud.

"When this old peasant was as young as his grandson, if his grandfather had seen *bourgeois* like ourselves around a sand-heap, he would have looked upon them with distrust, and the child would have thrown stones at them."

"Would they, and why?"

"Because ignorance in the country, and even in the

suburbs of large cities, was so great that the people were ready to look upon any act as dangerous which they did not understand. In every man dressed as a *bourgeois*, with a sketch-book and surveying-instruments, they saw only a tax-gatherer, revenue-officer, or a clerk, charged with levying new taxes on their property, or rather with taking it away from them.

"There were good reasons why the peasant learned to distrust all who were above him; and on account of his ignorance, prejudice, and superstition, he showed only hostility to every one who took particular notice of any thing near his field or village.

"When very young, — eighteen or twenty years old, — I happened to be in a village of Burgundy, drawing one or two houses whose very primitive construction interested me. I paid no attention to the hostile attitude of several villagers; and soon one of them, approaching suddenly, asked what I was doing.

"'As you see,' I answered, 'I am drawing this house.'

"'Does any one wish to destroy it?'

"'I do not know; at all events, I shall not destroy it by drawing it.'

"'Perhaps you intend to set fire to it.' The circle of villagers, men, women, and children, closed around me during this dialogue.

"'He must be taken to the mayor's! he is an incendiary! he is an excise-officer!'

"The good people began to threaten, and became excited, and shouted this in chorus.

"I was rather rudely escorted to the mayor, who lived more than two kilometres distant. At the sight of my papers (for it was then prudent to have a formally drawn passport), the municipal magistrate left me free to go my way, but advised me not to tarry too long, or to examine houses in which there was nothing to see, although my intentions might be good.

"And when later, having been ordered to locate a railroad, we planted stakes in the fields, Heaven knows what insults we endured, in spite of our official documents and the protection of the authorities. The first balloons which descended in the country were torn to pieces by the peasants, and aëronauts were often abused as sorcerers or persons in league with the Devil. Happily things have greatly changed; and now all over France, topographers, scientific men, students, botanists, geologists, engineers, and aëronauts, meet with hospitable reception, aid, and protection from the people; and, though education is not yet sufficiently general, people have learned at least to respect it, and recognize its influence for good. Therefore it is necessary to educate one's self, and to teach others whenever an opportunity presents itself.

"In a civilized country no one has the right to reserve to himself what he knows, and one may be as guilty of being miserly of his knowledge as of his property.

"This is why one should teach his fellow-being whenever an opportunity offers. Who knows but the elementary lesson in levelling which you have just given this good man and his grandson may develop in the latter the desire to know more, and be the first seed sown in the mind of a future *savant?*"

CHAPTER XII.

A MUTUAL AGREEMENT.

EVERY day M. Majorin opened a new field of study to his pupil.

His method consisted in sowing in his youthful mind all those principles of general knowledge for which the practice of drawing is necessary, in order to make him understand the usefulness of this form of language, which is too often wrongly held to be a special art, while, on the contrary, it is simply complemental like the art of writing and speaking.

He considered his pupil's natural taste for drawing, and, knowing how easily natural talent falls into a career which has for its aim only the production of the purely artistic, he believed that one should always study how to apply drawing to a direct object, — to the study of a science or the exercise of a profession.

The six months, at whose expiration M. Majorin was to finally decide as to the future of the son of Loupeau,

had passed. The teacher was attached to the pupil, and firmly intended to keep him; but, being scrupulous in every thing, he thought best not to make this final engagement without consulting the child, although he believed that he would gladly remain.

He did not think he had a right to thus dispose even of a minor, although with the consent of his natural guardians, without having secured his consent.

One evening, therefore, when he was about to retire, M. Majorin said to Jean, —

"My dear, it was agreed that after you had remained six months I might send you to your family if you did not answer my expectations, or if it should please you to return. The six months have expired. For my part, I wish to continue to teach you, and to have you educated to the best of my ability; but you may make other plans if you think best, and return to Boissy-Saint-Léger. Of course, I in no way bind your parents, who can at any time take you back; I bind only myself, and that to a certain extent: but I ought to ask you first if you fully agree to the proposition. Take time to reflect. I do not require an answer to-day; but I must perfectly understand your opinion. Therefore consider it."

Jean stared with surprise when M. Majorin began to speak, who, seeing his emotion, continued, —

"You must not misunderstand what I say. I wish to keep you; but I shall leave you free to choose, although you are not yet your own master.

"You must know that if your parents, now or later, do not object to your stay with me, but, on the contrary, fully and always consent, you will remain under my guidance till your majority, or until the age when you alone are responsible for your acts. You understand, therefore, that I speak in this manner because I do not wish to influence your opinion, or that you should ever reproach me for not respecting it. Therefore, express it freely, but not until after due deliberation."

"Why," answered Jean in tears, "you know very well that I wish to remain with you!"

"I would gladly think so; but you have lived too pleasantly during these six months, while we have worked to amuse ourselves. You must not believe that it will always be so. If you remain, it is because I wish to make you a learned man, capable of creditably following a profession, and of being useful to others and to himself. To succeed you must work hard, and go to the roots of several branches of knowledge which in a pleasant way we have only partially acquired.

"Have you the courage to devote yourself to assiduous labor for years for the sake of acquiring this knowledge? Consider this well. If after promising your parents to teach you, and to make you a man of ability, and to assist you, I should not find in you the love of work which alone assures the best results, you know what a heavy responsibility I should have undertaken, and how

your family might justly reproach me for assuming a task which I could not perform, and for having made of Jean an inefficient man, a person incapable of even supporting himself, much less of assisting his family.

"Therefore, I repeat, do not decide until after mature consideration.

"I know you well enough to feel certain that you are an honest lad; so, if you follow my plans, I shall be sure that at the same time you will have pledged yourself to work steadily, and to respectfully follow my advice. If you do not feel in yourself enough capacity and strength to do so, I believe that you are too honest to deceive me. In this case, in order to avoid mutual regrets, and to prevent any ill feeling of your parents towards me, it would be better for you to say frankly, 'I am not sure of my courage: take me back to my father and mother.' You cannot answer so serious a question in a few moments, and we will talk of it again to-morrow if you wish."

Jean went to bed rather heavy-hearted, and slept but little. The grave words of his friend recurred to his mind, and seemed to have a stronger emphasis; and the sober and earnest face and the eyes of M. Majorin, which looked steadily at him during his remarks, appeared before him in the darkness. At first Jean did not hesitate: the idea of returning to Boissy-Saint-Léger, and of living again in that country atmosphere of poverty which was never brightened by a gleam of humor from his father, was

by no means pleasing; but gradually the teacher's last words, and the responsibility which they imposed upon his pupil, made him somewhat fearful.

He felt that his teacher was right, and that his answers would bind or free him, as if he had signed, or refused to sign, a kind of irrevocable contract.

He was a little frightened at being legally bound; for the mind of a child at such an age, however careless it may be, considers every thing seriously, and according to conscience. For a moment he thought he could not pass through the ordeal which M. Majorin allowed him to foresee, and with this thought he fell asleep.

But night brings counsel; and in the morning, when dame Orphise awakened him that he might get ready for school, the fears of the night had vanished.

Out-of-door air, school-work, and the energy of youth, overcame his hesitation; and when he returned to the factory to dine, he eagerly went, with a joyful face, and threw himself into the arms of his friend, saying, —

"Yes, yes, I will remain with you: I will work, and become a man."

"That is well," was M. Majorin's simple answer; "but never forget this resolve."

The instruction which could be afforded by the primary school which Jean attended would soon no longer suffice. There was at that time an institution at Bourg-la-Reine, directed by a very learned man. In addition to requiring

a study of the classics, particularly of Latin, — which cannot be neglected, because it relates to the past of our nation, — it devoted much time to mathematics and physics, to experimental chemistry, and to instruction in the trades.

A very large garden belonging to the establishment permitted the study of horticulture and botany; and, besides, the institution furnished every year a respectable quota to the Central School of arts and trades, and to other special schools.

M. Majorin decided to have his pupil enter this institution as a day-scholar, for he determined to keep him neaı him, and to watch his progress. During the summer before his admission, Jean advanced rapidly in the study of geometry; which, however, did not prevent him from drawing from nature, and usually in the open air.

M. Majorin wished to accustom him to draw in every position; standing, and sideways as regards the model, so that to reproduce the object he might be obliged to turn his head and to draw backwards, or to place at the right what was at the left, and *vice versa*, as engravers do.

When both were standing before a building, or before a tract of uneven ground, M. Majorin made Jean notice the prominent points, the arrangement of the shadows, and the inclination of the ground, and reproduce in the evening this building or place, from memory. On the following days they would verify on the spot the accuracy of the drawing.

Jean in this way made very marked progress, and greatly pleased his teacher; already when he wished to explain any building, or inclination of the ground, or to describe an object, he drew a sketch to make it clearer.

His teacher never failed to correct faults of perspective or of outlines.

That his pupil might be skilful with his hands, he furnished him with several tools, and taught him their use. "One cannot draw an object well," he said, "unless one is able to model, shape, and fashion it, and to supply what drawing gives only after much time and labor, and many explanations."

They were then erecting on the factory-grounds a large framed workshop of a peculiar construction, and having on the sides galleries for the purpose of communication.

Jean profited by every occasion to watch this work, and was intimate with the foreman of the workmen. Moreover, he wished to make the model of a bay of the workshop, which was composed of many rafters.

It was necessary that Jean should first set up one of these rafters, half of which is represented in Fig. 68, and copy his numbered sketches in order to observe relative dimensions. Having done this, and having been furnished by the foreman with pieces of wood squared to the scale required, to four centimetres to the metre, he began as he had seen the workmen on the frame; and, placing these pieces of wood on the diagram prepared by him according

to this scale, he cut them in turn, and united them after considerable labor.

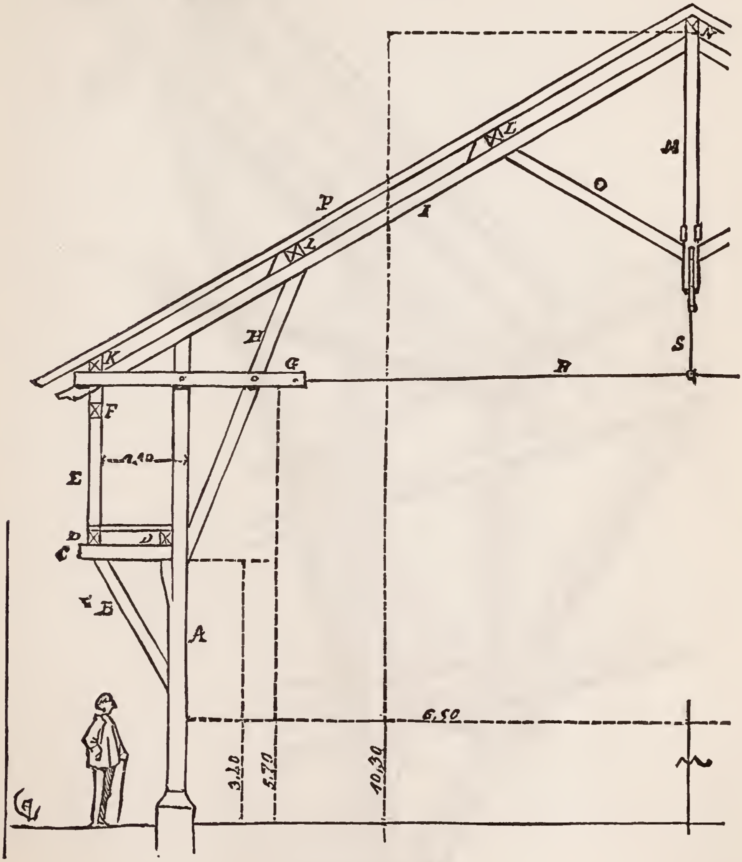


FIG. 68.—A FRAME.

This work interested him so much that he devoted two hours to it in the morning. Then, in the evening, by

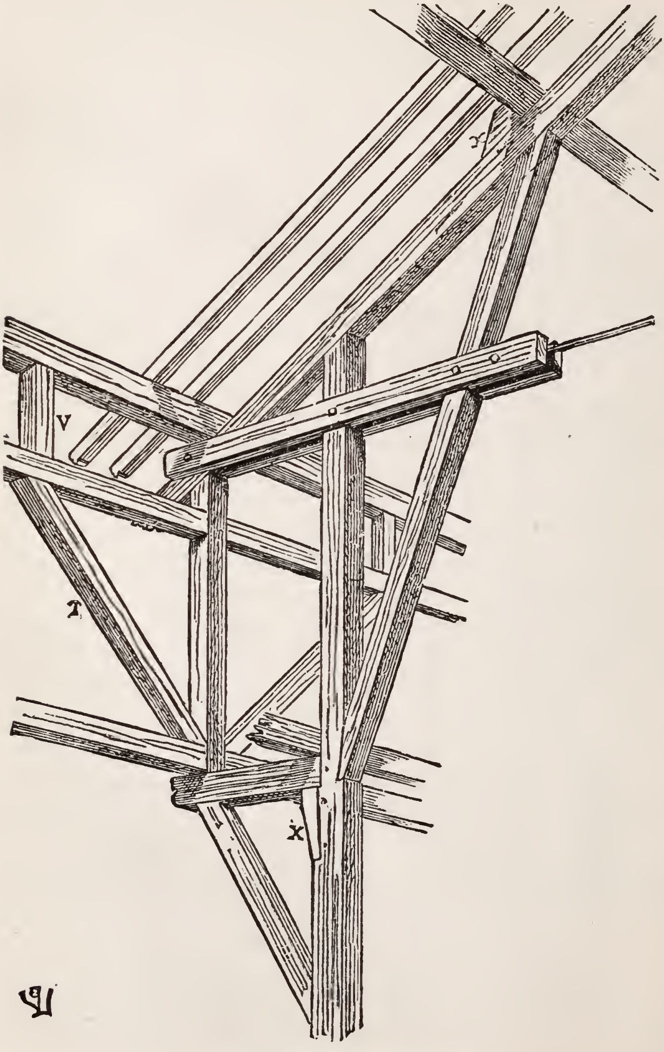


FIG. 69.—DETAILS OF FRAME.

lamp-light, he drew, from various points of view, the united parts (Fig. 69), and M. Majorin made him write down their names.[1] When the carpenters set up the frame, Jean sketched the gang (Fig. 70), which he found very difficult.

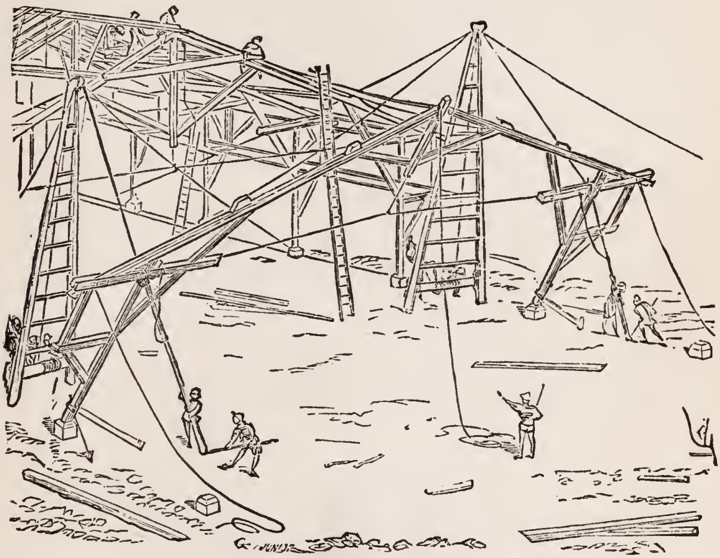


Fig. 70.—Raising a Frame. A Sketch from Nature.

Being naturally conscientious, he was eager to complete what he undertook, and, the more readily he drew, the more he tried to gather material. Following M. Majorins' instructions, he arranged his notes with system, and classified them according to their kind.

[1] A, post; B, truss; C, landing-place; D, filets; E, struts; F, transom; G, braces; H, principal rafter; I, rafter; K, raising-piece; L, longitudinal rafter; M, king-post; N, ridge-piece; O, bands; P, rafters; R, iron brace; S, suspension rod *idem* (Fig. 68); T, supports; V, struts; X, brackets (Fig. 69).

M. Majorin had shown him his portfolios, and how the sketches or notes which filled them were arranged, so that he could easily find the information he needed. "It is not enough," he said, "to have riches, but one must also learn how to use them." Many persons accumulate notes; but, being unable to find them when they are needed, they are of no use to them. System and classification are essential conditions in successful work." Jean showed so much ardor in filling his portfolios, that M. Majorin, thinking he was too young to work so steadily, and fearful of overtaxing his mind, took advantage of vacation-time, when he himself could leave the factory, and travelled a short distance with him.

To Jean's great delight, on the 2d of August, 18—, M. Majorin and he arrived at Dieppe at eleven o'clock in the evening.

CHAPTER XIII.

JEAN'S FIRST JOURNEY.

THE next morning they rose very early; though Jean did not know why the trip was made, M. Majorin having said very little about it.

When he saw ships at anchor in the docks, he was greatly astonished; and as they reached the brow of the cliff, having taken a road which led up behind the castle, the sea suddenly appeared. M. Majorin closely watched his face in order to draw inferences from the impression made upon him. He remembered that when he was a child his father took him this same journey: they travelled in those days in a diligence; and when at evening it reached the top of the hill, which the passengers ascended on foot as was the custom, the horizon and the town of Dieppe outlined against the broad expanse of water suddenly met their gaze.

For some moments a distant murmur was heard; and he remembered the deep impression made upon him when

this vast horizon, dividing sky and water in a dark, sharp line, opened before him like a sudden revelation.

At that time the freshness of such grand views had not been spoiled for children by a previous description; and M. Majorin's father, a merchant in the Rue Saint-Denis, who was any thing but a poet, saw in the sea only a very broad and rather unsafe passage open to colonial trade. The idea never entered the child's head, of confiding to his father his feelings at beholding the magnificent view; but he kept them to himself, and they were indelibly stamped on his mind. Thinking, rightly perhaps, that he must let Nature give her own impressions of her grandeur, M. Majorin would not stimulate the expectations of his pupil, and he avoided weakening them by the commonplace and pompous descriptions so much in fashion to-day. And in fact, thought M. Majorin, those whom these sights naturally move have no need to have their emotions awakened or described; and descriptions, however brilliant, cannot move those who are indifferent to the splendors of nature.

This, perhaps, was rather severe reasoning; but, as mentioned before, M. Majorin was eccentric. He looked anxiously at Jean, who stopped, and exclaimed, —

"It is the sea!"

"Yes, it is the sea."

"How grand it is! let us sit down."

"No: we will go nearer the edge of the cliff."

Jean paid so little heed to where he was walking, that he tripped in the grass at every step.

Some children jump and shout with joy in the presence of what causes them deep emotion; while others, on the contrary, become serious, and seem to be deep in thought, and remain motionless and silent in order to lose none of the sensations they feel. Jean evidently belonged to this second class, and M. Majorin inwardly congratulated himself; so, when they reached the edge of the cliff, both sat down, and were silent for some minutes.

"How high the horizon is!" said Jean at length.

"It is no higher than your eye."

"But it seems so."

"That is because the surface of the sea does not present a series of planes separated from each other, and you do not get an exact idea of the distance of the horizon. But look closely in that direction: do you not see a dim speck on the line which is the apparent limit of the sea?"

"Oh, yes, sir!"

"It is a ship, and must be quite large: do not lose sight of it for a moment, and you will have an idea of distance and of the horizon. The sea will no longer seem to rise before you like a wall. Look at the little foam-capped waves: do you notice how the white specks diminish in size the farther they are from the shore, and vanish long before the limit of the horizon is reached?"

After another pause Jean resumed,—

"Now I understand very well that the sea is flat."

"Horizontal, you mean?"

"Yes, sir, horizontal."

"At first you did not think it so?"

"I could not tell: it seemed to come to me all at once, — and at first it almost frightened me."

M. Majorin was pleased at this; for he found that his pupil was experiencing the same sensations that he himself felt when he was a child, when overcome with inexplicable terror at the unexpected glimpse of some magnificent scenery. He remembered how he shuddered, the first time he saw through a telescope the moon, and the strange elevations arising from its surface.

"Jean," he said to himself, "is a real observer. Among all the men who study nature, how few there are who receive an impression strong enough to be stamped on the mind! and how important it is not to efface these early impressions!"

The two friends were lost in meditation; and Jean, without understanding what he felt, was absorbed by these thoughts which the sea had given him, while M. Majorin renewed in all their freshness the feelings of his youth. Finally they arose.

"Good friend," said Jean, "why are these cliffs so straight?"

"Vertical, you mean: you must always use exact terms, as that is the only way to make yourself under-

stood. It is because the sea, crumbling away their base, has cut the wall vertically; and, further, because the character of the chalky formation has aided it. If the cliff had been clay, sand, sandstone, or granite, there would have been a different result. Examine the sides of this chalky cliff: they are worn away in the form of rhombs, and yet you will notice horizontal strata of silex at almost regular intervals (Fig. 71). This soft white earth, called chalk, is almost entirely composed of the shells of microscopic animals. This rock is only a thick calcareous bed formed by animalcules, and is sometimes almost two hundred metres thick. One is awe-struck at the thought of the time it must have taken these animalcules, which are almost invisible to the naked eye, to form this thick mass. The strata of pebbles, which are frequently found in the chalk, and especially here at Dieppe, are composed of silex which floats in the water in a gelatinous state, like gum, and adheres to an organic substance by filaments or nodules. These gelatinous nodules were deposited in the chalk, which was once under water itself, in the form of paste (it still has this form in certain parts of the ocean). When this chalk is dry it becomes hard, and this heap of silex also slowly hardens: the proof of which is that many of these pebbles are now surrounded, as you will see, by a paste of adhesive chalk, penetrated by silex.

"'Why are these silicious nodules thus deposited in

Fig. 71.—Cliff at Dieppe.

regularly spaced strata?' you ask. I cannot tell. It must be supposed that periodically and at intervals, during the slow formation of the chalk, silica was produced in large quantities.

"I cannot tell you the cause, but can only affirm that such is the fact. The sea, in crumbling away the chalk, dissolves the white substance, and leaves pebbles of the silex, which, being very hard, are rolled in by the waves, and rounded by long-continued friction, and form these banks of pebbles which encroach upon the shores.

"You will understand why this white chalk is eaten away vertically when its base is undermined by the sea. Let us walk about a little; but hasten, as the tide is coming in, and we cannot much longer, for to-day at least, watch the action of the sea."

Having advanced about a hundred metres along the cliff, with the château behind them, they reached a break in the cliff, of which they discovered a portion still uncovered at the foot of the steep descent (Fig. 72).

"Look!" continued M. Majorin: "the sea has made a horizontal cut in these rocks to show you their composition. Notice these seams. They are fissures made in the chalk by the receding of the water and by desiccation; and they have divided it into rhombohedrons and prisms. The sea attacks one of these prisms at the base; and, when it has worn it away, the prism falls in a block, leaving intact the vertical wall of the prism not yet

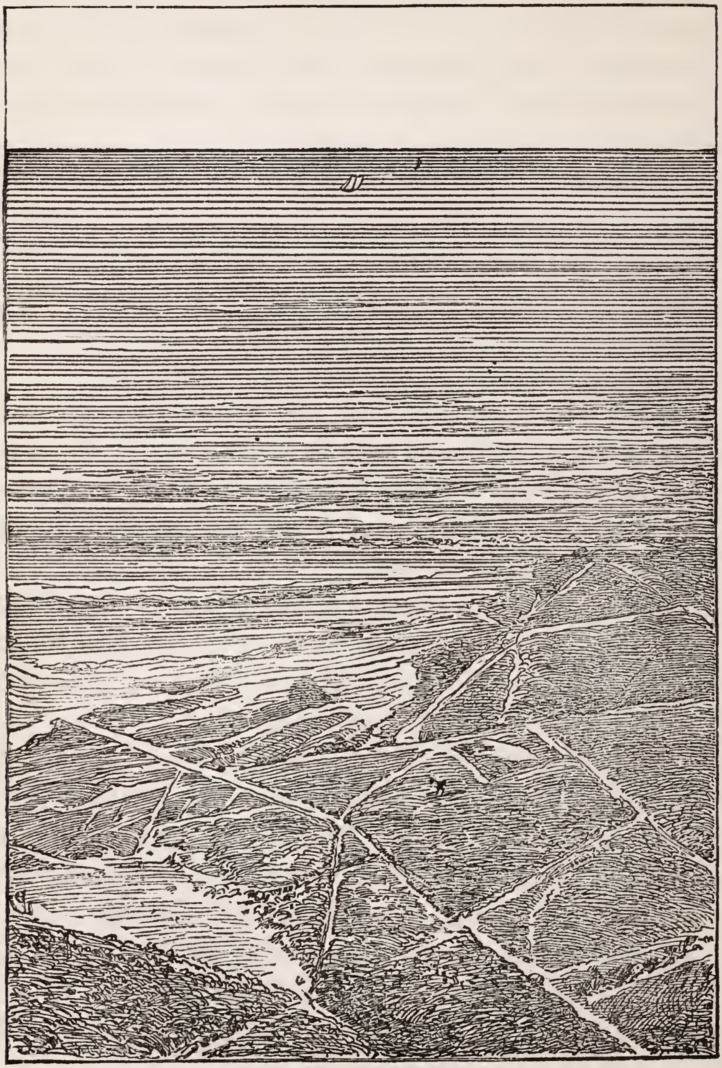


FIG. 72.—THE LINE OF CHALK AS MARKED BY THE SEA.

encroached upon. Thus the sea gradually destroys the mass by cutting it vertically."

"Are these great rhombs which the sea has just covered composed of chalk? All of them are black."

"The dark color which covers the horizontal seam in the chalk is due to algæ, dark marine plants, and black pebbles which are caught in the clefts; but at ebb-tide we will walk on the rocky shore, and you will see that chalk is still deposited far beneath the surface of the water."

"How fast the tide comes in!"

"Yes; and it is not well to linger at the foot of the cliff, for it may cut off our retreat."

"Formerly the cliffs were where these rhombs are?"

"Certainly, and they extended much farther: it is even possible that they joined those opposite, in England."

"And where was the sea?"

"Oh! it had enough room elsewhere; for what we have before us is only a canal, the canal of the Manche, which the sea has opened and enlarged to render easier communication from the north-east to the south-east, between England and France."

"Cannot we see the coasts of England?"

"No: they cannot be seen from here; for, on account of the earth being round, they are hidden from us, as this sketch will show you. (Fig. 73.) Here at A are the cliffs of France, and at B those of England: you see, that, in drawing a straight line tangent to the curve formed by

the sea, it passed above the cliffs B, and our horizon therefore is at the tangent point C.

Fig. 73.—Curving of the Earth.

"I understand very well that this convex sea perplexes you; but since it covers the earth, which is spherical, what we see must be a portion of a sphere. Remember what I told you when I explained how the horizon is always as high as the eye (Fig. 24), and you will understand how at this height one cannot see the coasts of England: if the cliff were three or four times higher, we could discover them, because we should see a more extended portion of the sphere, or, to speak more correctly, we should be at the top of a cone whose base would be broader."

Jean spent the whole day making sketches on the cliffs; and M. Majorin, who devoted himself to geological searches, corrected them, and showed him how the rocks, which present so irregular an appearance, always possess certain long lines, the result of their shape and formation.

"These," said he to Jean, as he looked over his drawings, "are the principal lines which one must always look for when one copies beds of earth, without paying attention to accidents of detail. When one draws rocks and

beds of earth, it is too often thought that their apparently irregular forms are due to chance; but it is not so, as they follow the immutable laws of formation, stratification, and crystallization.

"You will know this if ever we have an opportunity to visit together countries where these geological formations are numerous and varied."

"What is geology?" asked Jean.

"To be sure! I forgot to tell you.

"Geology is a science which treats of the natural history of the earth, and the successive layers which form its crust, and their relative age, and the changes which modified their first position."

"It must be very interesting."

"Indeed, it is a very attractive and very useful science; for, by examining its strata, one is able to ascertain if it contains coal, iron, lead, or copper, or building-materials, such as mortar and clay for brick, porcelain, china, and slate, moulding-sand, modelling-clay, or chalk to improve cultivated land. There is hardly any science more useful or more interesting.

"It has not long been applied to practical purposes; nor has it long been known that the crust of the earth formed slowly, growing gradually thicker; that certain elementary vegetables then began to cover it; and that animals of an inferior order, primitive mollusks, succeeded; then fishes, reptiles, birds, and mammals.

"Traces of these animals and vegetables were left in the soil in which they were buried, where we find them to-day; which has enabled us to classify the successive strata into periods corresponding with a particular condition of the globe."

"And what is there under the crust?"

"Evidently a very warm mass, perhaps in a state of fusion, which finds an opening through the mouths of volcanoes, and spreads over the crust."

"Is the crust very thick?"

"On the contrary, it is very thin compared to the diameter of the globe, — nearly what the shell of a hen's egg is compared to its contents."

"But what if it should crack?"

"It cracks sometimes to give vent to matter which volcanoes emit, or is rent internally, which causes earthquakes. This is not of much consequence to-day, for the crust is so thick that it cannot bulge; but, when it was thinner and more flexible, it was subject to terrible upheavals, which produced great chains of mountains, and vast depressions in which the ocean took refuge; so that between the top of the highest mountain, which is about eight thousand metres above the level of the sea, and the bottom of the sea which has been sounded to nine thousand metres, there is a difference of seventeen kilometres, which, however, is very little compared to the diameter of the earth."

After seeing the sun set in the ocean, a sight which delighted Jean, the friends thus chatting returned to the hotel.

"Good friend," said Jean, as the sun met the horizon, "why is not the sun rounder? it is perfectly flat."

"Because, the atmosphere being denser near the earth than at the zenith, the particles of water held in suspension are more numerous in the lower strata than in the upper, especially near the sea where the evaporation is considerable during the day. Now, these particles are so many little lenses placed between our eye and objects, which magnify the latter. When the sun or moon touches the horizon, it seems larger than at the zenith; and it increases in size by reason of the difference there is between the number of particles of water in a vertical

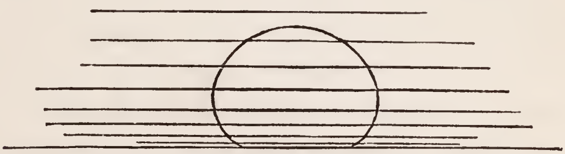


FIG. 74.—WHY THE SUN DOES NOT APPEAR SPHERICAL AT SUNSET.

and in a horizontal direction (Fig. 74). This figure will explain the phenomenon. The parallel horizontal lines indicate, by their greater or less distance apart, the weight of the air. You will suppose that between each of them there is an equal number of particles of water. It is clear, that, in the lower strata, these particles will be

nearer and closer to each other than in the upper, which are broader and lighter: they magnify objects, therefore, more below than above, and thus the sun will appear more misshapen horizontally than vertically, and flattened on the horizon. This is why, the higher one rises in the atmosphere, the smaller the diameter of the sun or moon appears when one looks at them in the zenith. A smaller number of particles of water being between them and our eye, they tend to resume the real size which perspective would give on account of their distance from the earth."

"Then, when there is fog the sun looks larger."

"No: fog is a mist from the water, and is already condensed; the particles are united in translucent but not transparent drops, which have not, like particles of water in a volatilized state, the power of lenses, or are not so divided and small that one can see through their atoms. When it is very fine weather, there is also considerable water in the atmosphere, especially near the ground; but it is volatilized. These drops cannot be distinguished as in the formation of clouds, or fog, which are the same. They are much smaller and transparent; and through them objects are seen very clearly, but they are magnified as if by millions of unseen lenses."

Jean did not quite understand this phenomenon; but the conversation, nevertheless, left a permanent impression on his mind. Of this M. Majorin was certain.

On account of such impressions it is very pernicious to give false ideas to children, because later on they oppose themselves to the proofs of science, and one can with great difficulty release himself from them.

The next day it rained, and they could not think of going out before breakfast; but from the window Jean saw the dock, and the ships lying at anchor. While M. Majorin was reading the papers, and attending to his correspondence, Jean took his sketch-book, and drew a small steamboat lying at the quay.

The drawing was a fair one (Fig. 75); and his teacher, who was not usually lavish of praise, complimented him. Jean had put the quay and all that was on it in correct perspective. He had ingeniously caught the shape of the vessel, which was loaded more heavily in the stern than in the bow. What pleased M. Majorin most was to see his pupil draw without choice all that attracted his attention, for he did not think there should be specialties in drawing. In his opinion, drawing was a means by which to represent every object, plants as well as animals, a rock as well as a tree, a statue as well as an ornament, a building as well as the human figure. Jean having succeeded in copying a vessel, M. Majorin, as soon as the rain was over, took him to the ship-yard on the beach, and showed how the hull of a ship was built, and explained where the pieces belonged, and how they were joined and fastened; and Jean sketched some of them.

The next day a surprise awaited him in the arrival of M. Mellinot and wife and André. The foster-brothers had not seen each other for a long time; and André, who

FIG. 75.—SKETCH OF THE PORT AT DIEPPE.

had entered college at the close of the last vacation, did not come to Hay until one day in Easter-week, when M. Majorin received a few friends, and when the children had little time to talk together.

Both were somewhat changed; but, after the first moment of surprise, they resumed their free companionship.

They walked about the suburbs of Dieppe as far as Arques, into the forest, and to the light-house. Jean always had a sketch-book in his pocket; and, whenever they stopped anywhere, he lost no opportunity to copy a cottage or a tree, a plant or barge. M. Majorin did not seem to attach importance to these attempts, though he was usually so interested in all that his pupil did: he wished to see if the taste which seemed to be developing in Jean would not be retarded by the seeming indifference of those around him. André, who had not touched a pencil since his entrance to college, did not know whether to make sport of his comrade or try to draw like him. At the sight of Jean's sketches, imperfect as they were, he was humiliated, the more so because Jean was not at all vain, and seemed to have no other thought than to follow a natural bent.

One day the children were sitting before a Normandy farm-gate, while Mme. Mellinot was busy preparing breakfast, and the gentlemen were walking and talking together under the trees. Jean looked at the gate some time, opened the sketch-book, and tried to copy what he saw. (Fig. 76.)

"What are you going to draw now?" asked André.

"That gate."

"Why?"

Fig. 76.—Normandy Farm-gate.

"Because I have never seen one like it."

"What is there about it, pray?"

"It is odd. It is made to shelter people while waiting, and also carts."

"Do you think so?"

"Certainly, my friend told me so; and then, the carpenter-work is pretty."

"What is there pretty in that old, decayed woodwork?"

"It is old, it is true, but it is well designed."

"A mass of wood."

"It pleases me, with those elms crowded against it like a wall."

"Are they elms?"

"Yes: my friend told me that the ancient Normans guarded their property in this way for defence, and that it is done now from habit."

"How did M. Majorin teach you to draw in this way every thing you see?"

"Why, by making me draw every thing at home first, from little models of houses, solids, plants, and skeletons."

"Skeletons?"

"Yes, skeletons."

"What for?"

"To know how we, as well as beasts, insects, and all kinds of things, are made."

"What next?"

"When he took me to walk, he said to me, 'Little

Jean, you must copy that.' I tried, and he corrected me, and gave the name of every thing for me to write on my sketch."

"Does he not correct your sketches now?"

"No, because he is busy with your father; but I know that he is satisfied if I draw something every day."

"You are to be a painter, papa says."

"A painter?"

"You are to make pictures to be sent to the exhibitions; but papa says that is not a trade."

"Oh! then my friend will not wish me to be a painter; for he has always said that when one is of age, he must hasten to learn a trade."

"What will you be?"

"I do not know."

"Since you are always drawing, it must be to learn a trade in which one draws."

"My friend told me that drawing is necessary in every trade."

"Indeed! Does papa draw? Yet he is a professor. Does my uncle draw? Yet he is a notary. And our friend M. Pommier, the physician, does not draw either. Only painters and architects draw."

"And engineers, since my friend draws."

"Oh, no! our cousin M. Planchert, papa always has said, does not draw at all, and yet he has a fine situation on the Lyons railroad: he is a great engineer, has received decorations, and dines at the minister's house."

Jean had no reply to make, therefore he continued his sketch without a word.

"Papa said the other day," continued André, "that it is necessary to learn drawing when one has left school, and has plenty of time. Do you continue your studies?"

"What studies?"

"Are you going to college?"

"No: after vacation I am to enter the institution of Bourg-la-Reine."

"Is Latin taught there?"

"My friend says that Latin is taught, for it is useful to every one."

"But, you know, it is not so interesting as drawing."

"My friend says that every thing is interesting when one wishes to work."

"Oh, no! not Latin or geometry."

"Yes, even geometry."

"Have you really learned it?"

"I have learned a little, and like it very much. I wished to learn more of it, but my friend said that I was not yet old enough: he has also taught me a little perspective."

"Perspective?"

"Yes, for one cannot draw without knowing it."

"But the big boys at college have a drawing-class, and there are some who draw very well, and receive prizes, without having been taught perspective."

"What do they draw?"

"They copy beautiful lithographed models."

"Do they not draw out-of-doors, from nature?"

"Oh, no! the teacher I had at school, before I went to college, said it spoiled the touch, and that you must first copy real models."

Jean glanced at his hand: the conversation troubled him somewhat, and his sketch was very bad, so he suddenly closed his book.

"It is too difficult," he said, and the two boys joined M. Mellinot and M. Majorin.

"Let me see what you have done," said the latter to Jean.

"Oh! nothing, sir: I could not draw."

"Did you try?"

"I tried, but it is very difficult."

"Let me see. That is not bad for a beginning," said M. Majorin, looking at his pupil's rough sketch: "you should have continued."

And, closing the album without adding more, he returned it to Jean. The child felt ill at ease; for André's talk and the unusual coldness of M. Majorin troubled him. The daily contact with a kind heart, interested in the slightest details of the pupil's education, had not armed the latter against the wounds his pride might receive.

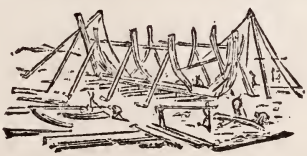
M. Mellinot said nothing about the kind of studies adopted by M. Majorin, but discoursed on the instruction

given in college, and on the advantage of classical studies. M. Majorin avoided discussion in the presence of the boys, and even seemed to approve what his friend said.

Jean suddenly found himself alone, and in a strange atmosphere.

At breakfast he was silent, and did not eat, while André appeared livelier than usual. Without knowing why, — for the boy was not malicious, — he felt a secret satisfaction that his talk had disturbed the mind of his foster-brother; for the kind of superiority acquired by Jean, who appeared to know so many things already, annoyed him.

These contrary sentiments in the boys did not escape M. Majorin. He did not regard as trifles the strong feelings of children on unimportant subjects; but, on the contrary, he believed that these first impressions might have a determining influence in forming their minds, however frivolous the subject. He therefore watched his pupil during M. Mellinot's stay at Dieppe, without showing further attention to what Jean did or thought; who, until André's departure, no longer carried his album with him when he walked.



CHAPTER XIV.

THE ADVANTAGES AND DISADVANTAGES OF GOING OUT OF THE BEATEN TRACK.

IT must be confessed, that, after the Mellinots were escorted to the station by M. Majorin and Jean, the latter felt relieved; although he had passed charming days with André on the shore and in the walks about the neighborhood. But the boys no longer seemed to speak the same language. Jean called every thing by its real name: for example, when speaking of a pebble, he said, "It is a silex; let us see if it contains a geode." A shell was a "bivalve;" the brown balls they found on the shore, iron "pyrites;" and a tree was an ash, beech, or oak.

The poor little fellow did not mean to be pedantic, but he had been taught to call every thing by its true name; which irritated André, who looked at him ironically, as if to say, "What is all this to me?"

When M. Majorin and Jean returned home, the latter

asked if they could not walk on the shore where there were marks of fissures in the chalk (Fig. 72).

"We will go there," said M. Majorin, "as it will be low tide for at least three hours."

This time Jean took his sketch-book, as his teacher noticed. They soon reached the rocky shore, which was covered with algæ, bits of shells, and animalcules in pools of water and upon the rocks, and little crabs, and stranded sea-nettles; a whole world of living things, chasing, fighting, and killing each other. Jean overwhelmed his friend with questions, in his eagerness to hear his clear, interesting explanations, which filled his mind with thought, after these few days conversation with André the memory of which left a weight on his heart.

"Thus, you see," said M. Majorin, "the ocean is populated very differently from the earth. This immense body of salt water is filled with animals, from the whale to the microscopic infusoria, which are no less busy in this watery world, for they are the principal agents in forming the land.

"Formerly, the water on the globe, by making its inhabitants work incessantly, deposited a considerable part of the rocks which compose our continents, and which emerged when the crust changed its form. To-day the sea, driven back to the lowest portion, continues to make its population work exactly as of old: it still makes chalk, and coral reefs, which in their turn will form con-

tinents if the surface of the earth is again upheaved. Then we, in our turn, perhaps, will be at the bottom of the ocean; and on our cities the sea will deposit calcareous beds, sand, and the *débris* of mountains of silex reduced to dust."

"Will it happen soon?"

"It is not probable: we shall be warned. Besides, nature never works suddenly. There are coasts, like those in the West of Ireland, and even those of France, which are gradually sinking; so that in a certain number of thousands of centuries, the sea would beat against the ramparts of Paris, if Paris should exist at that time. Other coasts, on the contrary, are rising. Nothing in this lower world is in repose nor in a permanent state, and every thing in the universe is moving and changing, decomposing and combining, in a word, working; for work is nothing but motion, analysis and synthesis, that is to say, decomposition, and recomposition under a form that is sometimes similar, but never identical. Do you understand me?"

"Oh, yes, sir!"

Indeed, Jean seemed eagerly to drink in his teacher's words, which, after the broken conversations of the past few days, produced upon him the effect of a clear melody after discordant music; if he had not been restrained by a kind of bashfulness, he would have thrown himself upon M. Majorin's neck. The latter was aware of his feelings, and continued thus:—

"All these creatures that swarm under your feet have but one motive, — to live; and, in order to live, the majority of them must devour other animals, if they do not devour each other, as men, who are looked upon as very superior animals, have done, and still are doing. While living, these creatures work unconsciously to form the crust of the earth on which we walk, which we cultivate, and from which we take our building-stones, our lime, and a number of materials used for industrial purposes. Every thing, therefore, works, or destroys one thing to create another. Matter, which the ignorant suppose to be inert, works, for it is perpetually in motion. The vegetables are the most active workers on the globe. They make the earth healthy by taking from it for their nourishment the putrid fermentations which are poisonous to men; and the air healthy by absorbing the carbonic acid which every animal exhales in breathing, and which is also a poison to his kind. Vegetables retain in the ground, the moisture from which arise the springs that make the rivers; and when they die they leave to their successors a source of sustenance.

"Man, like all animals, is subject to decomposition and change; and his body, in spite of him, works according to their fixed laws. Yet one superior quality must be recognized in him, — intelligence. He rules over all the living creatures on the globe, on account of the more perfect organization of his brain. He has the power to ex-

ercise this intelligence, or not; but, if he does not, he acts contrary to nature, and is guilty, because a knowledge of what he does or does not do is given him.

"Thus the sentiment of duty is born in man, as well as the knowledge of what is right and wrong, that is to say, of social morals.

"Here is a crab, a little larger than its neighbors, ready to devour a poor little one of its kind that is injured and dying. Is it not shameful! But would you send the crab to the court of assizes? If you crush it to punish it, you are foolish; for punishment is only beneficial when the one who bears it understands why it is inflicted. Now, it is certain that this crab will not, in the least, understand why you destroy it. But if a strong man should throw himself upon a wounded child, incapable of defending itself, and devour it, you would not only be shocked, but you would think it your duty to punish the guilty if you could not avenge the victim.

"Well, the knowledge and performance of the duty which your judgment points out, and whose limits education defines, is the finest attribute of man, and the one which establishes his superiority over all animals. Among his duties the perfecting of his own mind is the most important, since it permits him to define and perform others. I repeat that men are guilty, in regard to their fellow-beings, when, having within their reach the means to learn, and to elevate their minds by knowledge, they

remain in ignorance and idleness, and forget for an instant, that, according to the order of nature, they were created to work."

"Oh, I know, sir, that it is necessary to work!"

"I hope that you understand me."

"It has cost me a great deal lately to be idle."

"Do not think that you were doing nothing: you were observing and comparing, and feeling the need of resuming our studies: you had both good and bad feelings, which you could not quite understand, but which we should not have had an opportunity to analyze if you had not experienced them. I conjectured what was passing in your mind those few days. In the first place, you felt wounded at not being the only one to absorb attention. When we are by ourselves I am naturally occupied with you, and you are thus rather accustomed to be the object of interest, which is bad for you. Then, perhaps, André made you feel that the instruction you receive is not like what he receives.

"Then, finally, the indifference of those about you, to your humble efforts, aroused ill-humor in you. Do I not speak the truth?"

"I believe so, sir."

"It set your brain to working; and you perhaps drew false deductions from appearances, which were nevertheless efforts to extract the truth from matters which concerned yourself, in order to understand men, and what they think of you.

"Well, from these reflections and intellectual labor, one can and ought to find the means to improve himself, and thus perform his duties more perfectly.

"There are two paths in life open to us. One is the broad one, over which pass the greatest number, and by which one reaches one's destination more or less rapidly, and impeded only by the large crowd. There are cross-roads that are difficult to travel, rough with briers, and full of bogs, but which lead one to the end more quickly if one has the strength and courage to overcome obstacles. Your comrade André, guided by his father, is certainly following the broad travelled road. I can take you only through the cross-roads: therefore, if you wish to follow them, you must have a great deal of courage and perseverance, and, above all, have no regret at having taken them. But there is yet time. You can, if you wish, like your brother André, enter college, which is the broad road; but I cannot guide you. If, on the contrary, you prefer to follow the course of education which I am now giving you, you must expect to meet with disappointments, and to seek in yourself alone the courage to go forward, without caring what those on the broad road are thinking and doing.

"Perhaps you do not quite understand me."

"I shall have courage, sir, if I am near you. André told me that what they taught him at college was tiresome, but every thing that you teach interests me."

"I believe so. But you have already seen that when you met people who were really kind you felt wounded. It did not seem to you that they estimated your acquirements at their worth; your slight accomplishments, if you have acquired any, caused more astonishment than approbation.

"How will it be when you possess real knowledge, and are in the presence of unfriendly or envious persons, if you are not armed against their ill-will, if you have not in yourself the energy which enables you to overcome difficulties, and if you are not certain that your strength will carry you to the end? I think I have made you understand how we are all put in this world to work. But that is not all. The majority of persons think one should work in a certain way, and not have a method of his own. This respectable majority have what is called a fixed course, which is the broad beaten road of which I have spoken; and they are displeased if it is not followed, although it may be crowded.

"They suppose that the weariness of travelling this broad level road is one of the conditions of labor, and do not admit that one can learn and work with pleasure. You are too young yet for me to explain this, and how and why work was given to man as a burden or punishment, while, at the same time, it should be his glory and the noblest of his enjoyments. If, as you say, our way of working and learning gains your interest, you must

expect to pay for this satisfaction; for all who have worked and learned through weary labor, or by making painful efforts, cannot admit that the knowledge acquired through pleasure can have equal worth.

"What I tell you is very serious for your little head; but you will think about it, and later it will return to your memory. What I mean is that you are now warned, and will rely upon your courage. But the tide is coming in, and we must not tarry longer."

M. Majorin and his pupil spent five weeks in visiting Havre, Caen, Evreux, and Rouen; and in the latter city Jean made a number of sketches of parts of buildings. Therefore he became accustomed to draw every day all kinds of objects from nature, and M. Majorin never failed to give him helpful explanations.

CHAPTER XV.

FIVE YEARS LATER.

HAVING entered the institution of Bourg-la-Reine, Jean received what Sainte-Beuve calls an average education; which was sufficiently classical and professional, without being too much influenced by old ideas and university forms, and such as I would like to have the majority of our people receive. The advantages of this education, for those who are not ready to serve as faithful Levites at the altars of antiquity, are that it leaves one free to follow one's bent, and does not unreasonably prolong his studies; that it fits one to adopt later, if necessary, any particular branch of learning relating to antiquity; and that a young man when about sixteen or seventeen can apply himself without delay to what will be the principal occupation of his life.

Jean entered the institution at twelve, and left it at seventeen, having a sufficient knowledge of the ancient

authors to pursue classical studies if expedient. He was thoroughly grounded in elementary mathematics, and tolerably well instructed in physics and chemistry, and qualified to enter a special school after a preparation of a few months.

Meanwhile he did not neglect the study of drawing; although, in this institution as everywhere else at that time, the absence of method rendered instruction almost useless. But Jean had learned principles which are not soon forgotten, and his drawing-teacher had the good sense to leave him to do as he pleased. Therefore, putting aside the engraved models distributed to his schoolmates, he copied the few plaster models which adorned the class tables, or any object before him. Vacation, during which M. Majorin always showed him new things, also gave him an opportunity to study nature and perfect himself in the practice of drawing. We must state that the stock of knowledge brought by Jean, when he entered the institution at Bourg-la-Reine, had singularly facilitated his understanding what was taught him. If a Latin author were to be translated, Cæsar's Commentaries for example, he quickly understood passages that were perfectly obscure to his schoolmates. He made sketches on the margins of his versions to indicate the section of a vallum, the arrangement of a contravallation and its wooden towers, the form of an *agger*, or the construction of the famous bridge of the Rhine. Thanks

to the liberal spirit which prevailed in this institution, the professor was not shocked at this unusual proceeding, and even willingly discussed the translator's illustrations with the pupils. But Jean's delight was to show M. Majorin, on Sundays, his illustrated interpretations of the texts; and this gave rise to conversations which deeply interested the pupil, and made him particularly fond of these studies, which weary the minds of the majority of students.

How could it be otherwise, without representing the scenes that were thus made to pass before their eyes?

But we must confess that history, geography, and the mathematical and physical sciences were more particularly liked by Jean, either because of a natural taste or on account of the habit he had acquired through M. Majorin of interesting himself in positive things, and of reasoning.

Jean returned to his friend's house at Hay at the end of the school year 18—; and M. Majorin asked him at once if he had decided what profession he would adopt.

"I dare not say," answered Jean. "When I saw the beautiful objects of art which you showed me in museums, and explained them so well, it seemed to me that I would like to devote myself to painting or sculpture; and when you take me to see fine monuments, and tell me how they are built, I feel a desire to be an architect.

"When we travelled through Auvergne, every thing

seemed to urge me to devote myself to geological studies, to become a mining engineer, or a topographer; but when we visit factories, and I see the wonderful machines, I think I will take up mechanics. I will, therefore, do whatever you advise."

"Oh, I shall take care not to decide the matter hastily! Since you yourself do not know what career you would follow, I know it even less; and it is too important a matter to settle without mature consideration.

"Parents too often decide the destinies of their children without reflection. From hearing it said that they will be lawyers or physicians, professors or engineers, or something of the kind, young men really imagine that they are born to follow one of these professions, and at twenty-five or thirty they discover, somewhat late, that their tastes or talents lead them elsewhere. We will not let it be so in your case."

M. Majorin, wishing to assure himself if there were the material for an artist in his pupil, made a bold test, and in a way that might allure Jean's mind, though it was somewhat reflective. He therefore placed before him some fine works that he owned, and they made a visit to the museums in Paris, carefully studying what they saw.

M. Majorin observed Jean attentively to note the impressions made by the masterpieces; and he soon learned that he was particularly apt at drawing conclusions, which indicated that his mind was scientific, rather than capable of inspiration.

One day while he was turning over some photographs collected by M. Majorin, taken from the works of antiquity and the Italian masters of the Renaissance, a drawing

Fig. 77. — Drawing by Leonardo da Vinci.

by Leonardo da Vinci, from the Florence Museum, attracted his attention, and he looked at it thoughtfully; which gave M. Majorin an opportunity to talk about this master.

"Yes," said he, "Leonardo da Vinci was an admirable artist and a *savant*. He foresaw the use of steam, as is proved by notes and sketches left by him and which we possess. He was a searcher for truth in advance of his age, and his works of art show a strangely mysterious mind. Evidently this genius felt that he was not perfectly understood, which did not prevent him from following out his researches; in his works there is always some kind of an enigma to decipher. This drawing (Fig. 77) proves it. This type of woman is one particularly his own, and one could recognize it among a thousand: the distinguishing mark in such a being is mind, but one full of mystery. When I was in the North of Italy I often sought the original of this type, but never found it. Where did Da Vinci find it? In his imagination perhaps; but (and this shows the man of genius) he has given it such life, and so complete an anatomical unity, and so individual a physiognomy, that one always recognizes the head, and wonders what these firm and delicate features mean and promise; the eye so soft and unfathomable, and the mouth so amiable and satirical.

"Leonardo da Vinci, who, in my opinion, is the greatest artist of the sixteenth century, absolutely refutes those who maintain that art and science are incompatible, and that the latter stifles all inspiration for art; and perhaps the greatest fault of our artists to-day in this learned century, in spite of their indisputable qualities, is unbe-

Fig. 78.—Facial Angle.

lief in this alliance, and failure to ask of science the support that it can give to art. The artist thus circumscribes at will the field in which he moves; and yet, because science leads to the discovery of the truth, and the truth is always superior to fiction, it would be for one's interest to look upon science as a useful friend. What inspired ideas artists would have if they would consult it! See, for example, these fragments of sculpture and Egyptian painting (Fig. 78); for these artists of remote antiquity of Egypt were wonderful observers. Here is a lion's head from Africa, whose contour has been caught with rare delicacy; here is evidently a caricature, half beast, half human. Now examine this head of a woman, which, on the whole, is charming, but in which there is something feline. The projection of the jaw, which is called *prognatism*, the distance between the corner of the eye and the nostrils, and the erect ear, were closely observed; for even to-day, among the fellahs on the banks of the Nile, we find this type, which suggests the feline. Compare this head with the drawing of Leonardo da Vinci. Do you not see what a very great distance separates the two individuals, and how observation, following the scientific method, may be useful to artists, and increase their resources?

"Does not the characteristic head of the colossal sphinx of Djîseh (Fig. 79) denote that among Egyptian artists, under the first dynasties, there was an admirable under-

standing of nature, and a singularly grand way of interpreting it. This head also is *prognathous;* but what power in those large eyes set close to the arched eyebrows, and

FIG. 79.—THE SPHINX OF DJÎSEH.

in the breadth of the lower jaw! It was through nature alone, and by observation of its strongest types, that these artists were able to give to this statuary an expression so noble, and also so peculiar, that their types are fixed in

the memory, and cannot be effaced: this sculpture, which is more than four thousand years old, gives to-day, very distinctly, the characteristic marks of the human races which then occupied the low valley of the Nile."

"Is this sculpture well preserved?"

"No: it has been mutilated by the hand of man; for time, in this protecting climate, has changed very little the rock out of which sculptors carved it. The nose is broken, and the eyeballs have been marred by the hammer; but the type is so marked, and the analogous parts are so numerous, that one cannot be mistaken as to the forms of those that are injured. Those Egyptian artists saw Nature in her grandest aspect, but, as scientific men, they studied her attentively; they discovered, in the first place, the principal characteristics of each individual, so as to secure the type: thus their works have a strength that overpowers whatever is placed near them.

"Volumes have been written on the *beautiful* in art, but all the paper that has been printed never caused a fine work to be made. It is because the beautiful, if any thing is meant by the word other than a kind of conventional law or form, comes from the manner of observing nature, and not from the reproduction of an eclectic type. The beautiful is harmony, the exact agreement of form with the function; and it is in this that science necessarily co-operates with art. Science proves that a certain peculiarity of the human skull, for example, necessarily

leads to a certain arrangement of all the parts. Scientific observation led Cuvier to reconstruct a whole animal out of a jaw or limb, and later discoveries have confirmed his statements. The artist who seeks the beautiful, or harmony, feels a greater interest in knowing how nature proceeds, and what are the logical consequences deduced from the construction of a part.

"Egyptian artists certainly did not practise anthropology; but with them delicacy of observation took the place of experimental science; and when one examines the oldest Egyptian works he will be surprised at the perfect harmony existing between typical parts of men or animals. Our modern *savants*, if they knew how to sculpture or draw, could not do better. But, unfortunately, our education is so defective, that, while our artists absolutely neglect science, our scientists are not able to use a pencil even tolerably well.

"You who already draw very well, and can perfect what you know, should remember, if you purpose following a scientific career, that drawing will give you facilities which are wanting to the majority of *savants;* and, if you wish to be an artist, science can give you a very marked superiority over those in your profession, and, above all, originality, which is the most important quality in art. Thus, in devoting yourself to art, bear in mind that you must have recourse to science; in devoting yourself to science, do not for a moment forget to

use the language of drawing, which not only describes the best, but, through practice, teaches one to see.

"Here, then, are works of art very different in character, separated by dozens of centuries, and sprung from civilizations strangers to each other, and also created by artists of races widely separated. I speak of the head by Leonardo da Vinci, and that of the sphinx of Djîseh; neither of which resembles the Venus de Milo we saw the other day at the Louvre. Both, however, are indisputably beautiful; and why? Because their authors sought in inexhaustible nature an element of art which they have brought forth in the form of a type, all parts of which are harmonious. Is it to be supposed by this that there may not be thousands of others, and that a work of art can be produced only on condition of adopting the methods employed in these two examples? By no means. Look, here is a book of Japanese engravings: we need not take the trouble to search the world, inasmuch as the Japanese are excellent draughtsmen. You need not ask these artists to reproduce the acknowledged types of the sculptors and painters of Egypt, Italy, the Renaissance, or ancient Greece; they have no knowledge of them: but they live in a peculiar atmosphere, surrounded by races who in no way resemble those of the West; they observe nature, and thus succeed in composing works of art of great value and of undoubted originality.

FIG. 80. — JAPANESE SKETCHES.

"See how they have succeeded in catching gestures and pantomime, and how all the individuals in their sketches are attending to their duties, and do not *pose* to lookers-on; how truthful and spirited their attitudes, and how full of life! (Fig. 80.) How proud this dignitary, clad in an ample robe of embroidered silk, with flowing sleeves, and with a sabre in his belt! for the Japanese upper classes always carry a fan and sabre. He is bearing some precious object in the most dignified manner. Is not the attitude of the elegantly-dressed woman examining a mushroom with the greatest attention as truthful as if drawn from life? And is not the other who is presenting a petition equally excellent? And has not the action of the porter been admirably represented? This book, which describes professions, games, and every act in life, is full of charming scenes, given with great spirit, which make us live side by side with the people as if we were in the centre of Japan. Do you think that our illustrations have this merit and charm? and do they render our daily customs and looks so perfectly? No: because we always have traditions, or fall into mannerisms when we try to be natural.

"The true and thoughtful love of nature, of the Japanese, appears in all their works of art.

"Evidently they have a singular love of it, as they so carefully observe it, and render its meanest products with great exactitude. To them every thing has interest: and

they study the form and habits of an insect, the appearance and parts of a plant, as well as the physical character of man; which does not, when necessary, prevent them from seeing only the *ensemble*, and from rendering by a few touches of the brush (for they draw little except with brushes) the general features of a landscape.

"Look through these three sketch-books, published in honor of one of the volcanoes of the country, which are full of scenes and landscapes of every kind.

"Observe how they are rendered, how by the simplest methods they give an exact idea of the country; and why? Because the artist has seized the principal points of each view to be produced, and, without adhering to details, has translated its strongest impression with extreme delicacy.

"Thus, like nature itself, he has unconsciously composed poetry. I say poetry: and I will explain myself; for on this subject, as on many others, we are imbued with conventional, and consequently in the majority of cases false, views, in so far as they pretend to limit, in a certain manner of presenting facts or impressions, a phenomenon which is applied to every thing, and seen everywhere, and under all circumstances.

"People generally attach to poetry the idea of fiction; and, the moment they have any thing to do with reality, will not admit that poetry or the poetic sentiment has any influence. It depends upon our definition: if by poetry is

meant the mythological, the supernatural, and the unreal pictures of the imagination, there is no difficulty or any thing equivocal. But if by poetry is meant a particular quality of impressions felt or communicated by sight, or the description of a natural fact, nothing would better combine its elements, which elevate the mind, than a careful observation of nature, or, in other words, scientific observation. If the Homeric songs have continued to give poetic style to us, it certainly is not because they present Aurora opening the gates of the East, or because Diomedes wounds a goddess; but because a number of passages depict the sentiments of the human heart (which are never fictions) in all their reality, and, one may say, their native harshness.

"However, there is a distinction to be made between the scientific and the poetic or artistic method.

"The scientific method consists in giving the smallest results of every observation, and in making a complete analysis of the object or the subject observed preparatory to a synthesis. Art or poetry can make this analysis, and consequently advance like science; but it ought to present only the general effect or the principal impression which is indelibly fixed in the mind. In this lies its merit and difficulty; for, to render this principal impression, one must feel it, although but few can, and although many in letters and arts believe themselves poets who are only appraisers taking an inventory. Well, to

return to these Japanese drawings: here is a certain scene, for example, which by the aid of a few lines and three colors represents a foam-crested wave moved by the wind; in the background are defined the outlines of trees and the summit of a volcano, Frou-Li. A flock of birds are wheeling round on a gray sky. The execution is very simple. But the lines are so happily studied and expressed, the shapes of the foam broken by the wind are so admirably interpreted, on account of an evidently close observation of details, that this sketch makes a deep impression. One can hear the shock of the waves and the crackling of the drops of water and the whistling of the wind. In a word, one is present at the scene.

"It must have been, that the artist who so powerfully rendered it, although it is so fleeting, received such an impression, and, in the working of the elements which compose the subject, singled out its predominant character and the accidental union of lines which picture it with so much spirit and truthfulness. The artist was a poet in the true meaning of the word, like the Greek rhapsodist, who, in two or three verses, paints the speechless attitude of the old men of Troy in the presence of Helen, who by chance passed them, though they overwhelmed her when out of sight with bitter taunts.

"A modern author would probably have prepared the *mise en scène* of this episode by describing the place, and the toilet and bearing of Helen as she approached; and it

is equally probable that in twenty-five hundred years his pains would be forgotten; while a few telling words were sufficient to enable this Greek rhapsodist to truthfully render this scene so that it would forever be fixed in the memory of man as the strongest expression of the influence of beauty upon human feelings.

"Science has another advantage, in that it needs to be treated sincerely and simply. It gives to the mind strong and healthy habits, which, instead of limiting the flight of imagination, gives it, on the contrary, more accuracy and scope, and prevents it from going astray.

"To-day, though *savants* have found their true path in observation and the experimental method, artists are still searching; and why? Because they dread the contact of science, believing it to be fatal to art; while, in a century like ours, it alone can supply the place of worn-out traditions."

CHAPTER XVI.

IN WHICH JEAN'S VOCATION IS FORESHADOWED.

SEVERAL days later M. Majorin said to Jean after dinner, —

"We are going to take a trip to Naples, and, if convenient for you, will leave to-morrow. I have business there relating to sulphur, and we will remain about twenty days."

Jean sprang from his chair.

"To Naples! what happiness!"

"We will not take much baggage: a hand-valise will be sufficient; for I do not like to wait at stations, and it is easier to carry it. Therefore to-morrow morning lay aside a change of garments, linen, and a few toilet-articles: Dame Orphise will pack them for you in a valise. A bag to strap over the shoulder and a travelling-wrap should complete the outfit."

Jean did not sleep that night, and rose at daybreak. They took the cars from Lyons at a quarter past seven in

the evening, and reached the station at Marseilles at twenty minutes of eleven in the morning. The boat left the next day, and put in to Genoa for an hour, which allowed the young man to sketch a small part of the harbor (Fig. 81).

FIG. 81.—SKETCH OF THE PORT OF GENOA.

At sight of the splendid horizons of the South, the blue sea, and the rocky isles brilliant in sunlight, Jean was transported with joy; and M. Majorin wondered if his pupil were not really born an artist.

They reached Naples towards evening; and Jean could not sufficiently admire the horizon defined along the mountain-tops and gilded by the setting sun, and rising higher and higher the farther the boat entered the gulf.

The two friends stopped at a good hotel on the Chiaïa, and after supper went out to take the fresh air on the promenade. The night was clear; and they were enabled to distinguish Capri, the mountains of Castellamare, and Vesuvius, from which slowly rose a plume of white smoke, which, reaching the upper part of the atmosphere, spread out like a parasol. All along the coast as far as the Torre-del-Greco were strewn luminous points, save where the Chateau de l'Œuf loomed up in sombre shadow.

The trip from Hay to Naples is enough to move the most indifferent nature; and Jean did not know whether he were awake, or under the spell of a beautiful dream. He felt angry with the promenaders who were busily chatting about their own concerns, without glancing at the beautiful sight freely offered to their admiration. He was never weary of looking at the volcano, and asked question after question about the causes of eruptions, their effects, and the phenomena which accompanied them, &c.

M. Majorin answered these questions according to habit, wondering meanwhile whether his pupil did not incline to be most interested in natural science.

"If at this time we can reach the summit of Vesuvius," he said, "rest easy, and we will go there, and you shall see it close at hand. It is of great interest to the observer."

Jean described the eruption as related by Pliny, which, after a repose of I know not how long a time, swallowed up cities; and he asked why the volcano had so suddenly awakened from its long sleep, and why since then it had continued to pour forth lava and ashes, and whether it would again be extinguished, and how the inhabitants could live so quietly at the foot of this ever-threatening crater, and why, without being discouraged, they again built on the lava which had just ingulfed them.

The next day, after M. Majorin had seen his correspondents, they went to Pompeii.

"It will be a test," thought M. Majorin; "and I shall know then for a certainty whether little Jean has in him the making of an artist, or whether his inclinations naturally tend to another kind of occupation."

In this M. Majorin was not mistaken.

This little city, arrested and embalmed in the full tide of antique life, produces various impressions according to the turn of mind of each person, leaving out of consideration the tourists who visit it simply from curiosity.

If the artist, who is only an artist, finds there an ample harvest of materials; if the historian and philosopher, visiting these ruins, are carried back to a civilization

different from their own, — the observing and the practical mind also discovers, in this petrified bit of an extinct world, very valuable principles which lead to singular deduction. Antiquity in *déshabille* appears very different from antiquity in the majestic and deceitful guise under which the classics represent it. It is found to be eminently practical and logical, but to surround whatever it used with a form of art inherent in the object. It is probable that we should have caused the Pompeians to shrug their shoulders, especially those who lived in Pompeii before the founding of the colony of Sylla, if we had spoken to them of *industrial art*, and of that academical distinction, which, in our times, is made between a pretended superior and an inferior art. At Pompeii ancient art shows itself what it really was, especially with the Greeks, as a natural quality, and not a borrowed adornment.

A Pompeian teacher would not have said what we heard from the lips of an eminent professor of one of our special schools, when speaking of a course of study to be given to pupils: "Above all, do not recommend the introduction of art." In truth, one wishes or does not wish art here or there, just as one wears or does not wear a diamond necklace. It is an extravagant luxury, which may become troublesome, and certainly is very costly, with but little practical utility. The lowliest citizens and shopkeepers in Pompeii did not so inade-

quately comprehend art; and one would have astonished them if, when asking for a saucepan, he had added, —

"Be sure and have no art about it."

While crossing the little city, M. Majorin found that his pupil, when his first astonishment was over, did not fail to ask questions which indicated something more than an inquisitive fondness for the picturesque.

He wished to know how the rooms were covered, how the bays were closed, and how the windows were set with glass, and how interiors were furnished, &c. M. Majorin answered these questions as clearly as possible. He showed Jean how the beams were bedded underneath the wainscoting, and how they were fastened; and the small museum at Pompeii exhibited its furniture, the framework moulded in ashes and obtained by casting.

All this seemed to interest the lad more than the fragments of sculpture.

"Our idea of antiquity is very far from what it should be," said the teacher; "and, notwithstanding modern research and discovery, we have not advanced beyond the appreciation which the sixteenth and seventeenth centuries had of the ancients; an appreciation more literary than critical, and which gives us the falsest ideas about their civilization. But," he added, "in all the productions of industry belonging to the ancients, there is a freedom and an individuality, which, notwithstanding their carelessness and faults in execution, make their

works interesting, because they represent, with remarkable sincerity, the habits and customs of man.

"The unexpected and original conceptions, formed through a freely expressed need or a personal desire, in the architectural works of that city, are surprising. There are but few rules besides those imposed by good sense and practice; or, at least, the application of the rules is singularly free.

"This is the fourth time that I have visited Pompeii and Herculaneum with the desire of studying their ruins. The numerous enterprises since 1860 have the merit over former ones, of having been managed with system, and of having preserved the traces which formerly were lost. Scrupulous care has been exercised so far as possible, and therefore the results obtained are really instructive.

"Errors have been rectified; and people are beginning to have correct information regarding the erection of these dwellings, and the manner in which they were ornamented with woodwork, and furnished.

"Let us first state that there are three well-defined epochs in the building of this little city. M. Fiorelli has classed them in the clearest manner in a recently published memoir. There are general methods which apply to all of them, and there are some which are peculiar to each of them. In the first place, stone without mortar was used with the wood; in the second, there was wood, and masonry of rubble-stone covered with plaster; in

the third, masonry of bricks and rubble-stone, and wood overlaid with thick plaster. But certain stone buildings of the first epoch, with sharp joints, were retouched, or rather covered again with plaster, according to the taste of the second or third epoch.

"Wood played a most important part in these constructions: it was used as lintels even under stone; to cover and enclose rooms; and for doors, casements, movable partitions, wainscoting, and frame-work, and finally for stationary or movable furniture. There were shutters to close these great bays, which separated the *impluvium* from the vestibule or from the *triclinium* (dining-room); and I am going to show you how they were closed and fastened by means of iron-work. The Pompeians manufactured clothes-presses like ours; the shops had their front of woodwork, with counters and iron safes; the museum at Pompeii and that at Naples will show you a number of them, either from castings from the moulds left by this furniture in the warm, moist ashes, or from paintings of interiors. But what one cannot too much admire in all this, and in their manufacture of the smallest utensils, is their taste and discrimination, and their choice of a form appropriate to the object, and, in a word, their art which directed every production.

"We will enter the little house near the temple of Venus.

"The *triclinium* looks upon the *impluvium* through a

large bay opening above a supporting-wall. You see by the woodwork how this bay was closed by shutters of wood with two leaves (Fig. 82). If one were cold, or

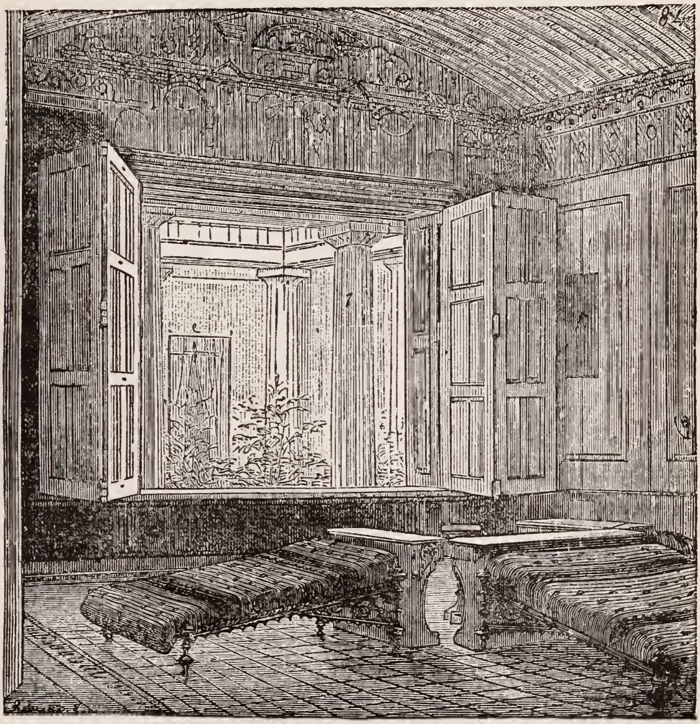


FIG. 82.—TRICLINIUM AT POMPEII.

wished to converse privately, he closed the shutters, and ate by candle-light; otherwise a view could be had of the *impluvium* or into another more spacious court;

for a second broad bay opened at the left in the same way under a portico surrounding a court, so that one could establish a current of air to avoid the great heat.

"But notice how well the coloring of walls was understood; how the dark basements bring out the brilliancy of the light falling upon the bushes and flowers which adorn the *impluvium;* how the yellow background of the nearest side-panels casts into the interior a gay, brilliant reflection, and the sombre red background of the next panels sheds a subdued light. The ceiling was made very light by white and blue tints, and delicate arabesques fill the space between it and the openings. Elsewhere we find traces of shutters moving on rollers, so as to shut easily. Many of the ceilings of these little rooms were arched, and were composed of plaster placed on reeds nailed to the joists, as is now done at Naples.

"You see here how these joists are fastened, and the ceiling arched. All these coatings were painted in the most charming manner, and with surprising variety.

"They would not accept commonplace painted paper; and their humblest dwellings had an appropriate although extremely simple decoration.

"But notice also how economical are the means of building employed, and with how little material these Pompeians knew how to make charming houses suited to the climate and their habits, without sacrificing any thing

to vanity; for, on the outside, all the houses, both of the rich or poor rarely presented more than plain walls, with but a few small grated windows, or shops kept by the proprietors or let to merchants. See how those rooms are arranged to receive the reflected light in a country where the brilliancy of the sun is dazzling, and how comfortable it must have been to live in such well-built houses.

"These Italian peoples joined to great sobriety and simplicity an elegance full of discrimination and taste. Compare this life to that of our inhabitants of small cities, who are strangers to the arts, and live outside of all intellectual life, and neglect them even as useless luxuries; who dwell in houses too often dirty, unattractive, and inconvenient (while here one sees that neatness was one of the essential conditions of life), and give more thought to their kitchen than to their library.

"As for the kitchens, in Pompeii they were neither vast nor complicated; one oven sufficing for the cooking of the family. You will see in the museum at Naples some of these portable kitchens which are works of true art, although very ingeniously planned in a practical point of view."

The custodians were obliged to notify M. Majorin that the time had come for visitors to leave, before they decided to return to Naples, Jean resolving to work there again, and to make many sketches.

The next day they went to the museum; and, when

Jean saw around him all the objects collected at Pompeii and Herculaneum, he understood still better what M. Majorin told him the evening before about the application of art to the most common utensils, and how art was always made use of with a view to utility. He would have liked to draw all these objects, and M. Majorin was obliged to insist on his examining each of these admirable collections before choosing his subjects. They therefore visited the hall of sculpture, the pictures, and jewels; but naturally Jean returned to the antique articles and paintings which revealed an unknown world. M. Majorin now acknowledged the aptitude of his pupil, and afterwards left him free to study and draw what most attracted him, either at Pompeii or Herculaneum, or at the museum at Naples.

As he was sketching a shovel and a pair of tongs (Fig. 83), he asked his friend why the latter was provided with a kind of guard.

"Can you not guess?" asked M. Majorin. "Reflect a moment: there is a good reason."

"Oh, I know!" said Jean, after a moment's pause: "that the handle may not touch the ground, and that one may easily take hold of it."

"You see, when the tongs are left on the ground, as the profile A shows you, that the handle does not touch it. Thus a convenience becomes a motive for ornament. It is the same with the two little appendages which project

from the shaft of the shovel, like the two ends of trimmed branches, and prevent the coals from falling towards the handle. But, in copying these objects, you must ask why such and such an ornament is adopted; for it is

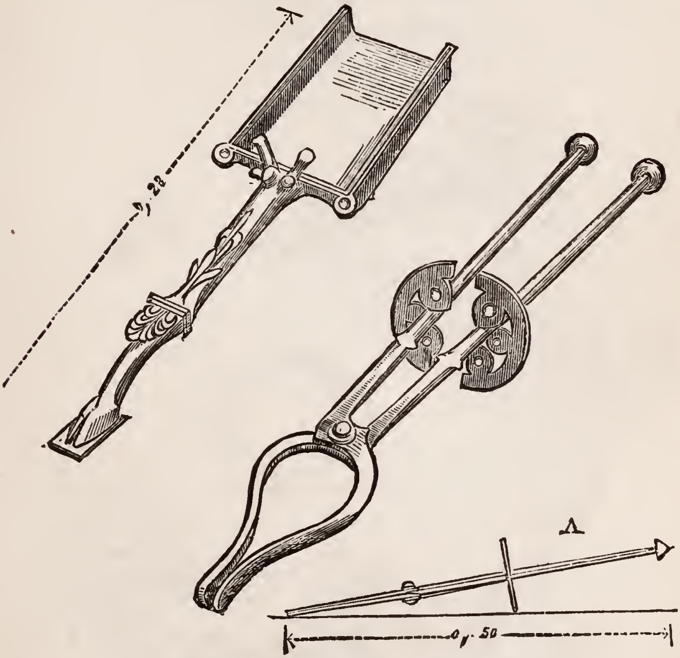


FIG. 83.—SHOVEL AND TONGS. (Museum at Naples.)

always because of some need; and that is why the ancients did not think the application of art to objects caused constraint, too often manifest in what we manufacture.

Examine the handles of this bronze drinking-cup

(Fig. 84). See the flower between the two lions: it is there for the thumb to rest upon, and to thus assure an easy hold. With two fingers under the belly of the lions, and the thumb on the flower, one can hold this charming vase without fear of letting it fall."

"I will copy those handles."

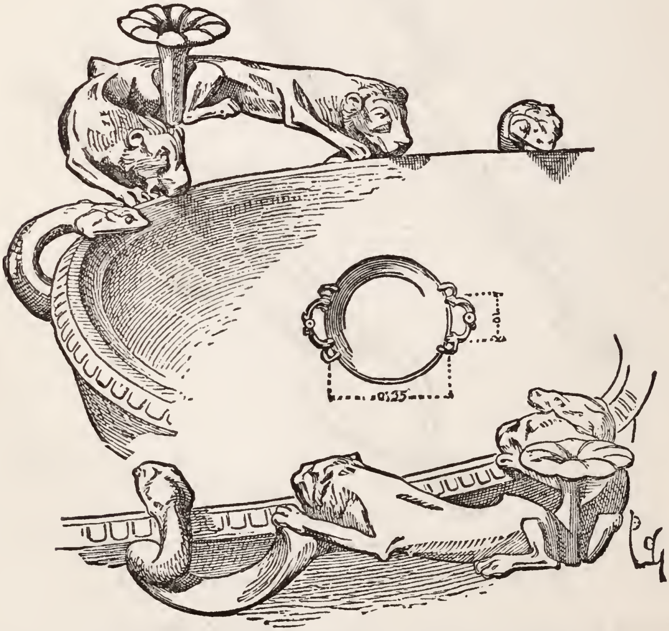


Fig. 84. — Handle of a Roman Cup. (Museum at Naples.)

"Do so; but do not forget to put a scale of measure on your sketches, for proportion is of importance in these

ancient compositions, and an ornamentation charming on a certain size would be ridiculous if it were diminished or enlarged. This is a rule that makes us produce ungraceful or unmeaning work, when it is negligently followed, or when, unmindful of it, we reproduce objects of antiquity, the middle ages, or the Renaissance; for the artists of those times did not think that such ornamentation could be indifferently applied to every degree of size.

"But at Pompeii we have seen kitchens in which one can hardly turn round, and which are provided with a raised hearth and a pipe to carry off the smoke. On these hearths they prepared a portable tray, like our tea-trays, which contained the repast.

"Here is one which is beautiful (Fig. 85), and worthy of careful attention.

"At A is a little fire-box, with a double bottom, with a hole to give air to the lighted charcoal. This fire-box is surrounded by a double lining, containing water, which communicates with the great cylindrical boiler B by the double walls C. On the three bronze swans which crowned the fire-box was placed the vessel which contained the meats, fish, or vegetables; then on the floor, which had a lining of wrought iron, several dishes could be cooked by means of coals or embers. If they wished warm water, they opened the faucet R. A small antique head placed at M, on the upper part of the cylinder, let the steam

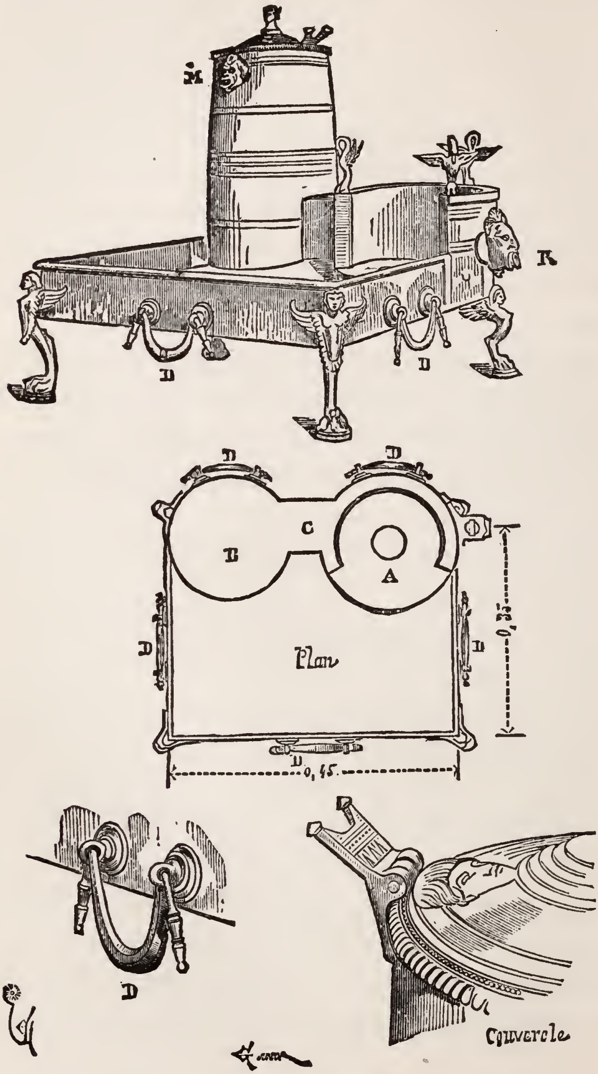


FIG. 85.—PORTABLE ANTIQUE KITCHEN. (Museum at Naples.)

escape; and the handles D enabled the slaves to easily carry this kitchen, when the dishes were ready, to the small table occupying the centre of the *triclinium.* Thus the dishes were kept warm during the repast, the remains of the burning ashes being still on the tray. The ancients often used warm drinks while eating; and you will see besides this sample a number of other kettles, some resembling the Russian *samovar*, which may be of Greek origin.

"This bronze cooking-tray, which comes from Herculaneum, deserves careful study. It is well for you to understand how it is made. Its ornamentation is charming; and it is well to study it in its details, for it is singularly appropriate.

"But since you now understand it as a whole and in its details, I call your attention to this stand (Fig. 86), which was probably made to rest in the middle of one of these *triclinia.* This beautiful bronze pedestal which represents winged Victory in front of the god Terminus, and bearing a trophy, supported a marble table, on which the dishes were placed before being served to the guests; for the meats were carved by slaves, and presented to each guest as he reclined around the triclinium on an inclined lounge which had a shelf at the upper end. Several of these bronze lounges are still preserved at the museum.

"We must not overlook this bronze footstool inlaid with red copper and silver (Fig. 87), whose ornamentation is so

Fig. 86. — Ancient Bronze Stand. (Museum at Naples.)

pleasing (Fig. 88). This kind of a footstool, provided with a strap and cushion, was placed before seats of honor, some specimens of which the museum contains, particularly the one in Fig. 89, which is a wonderful work of bronze inlaid with white copper on the listels *a*."

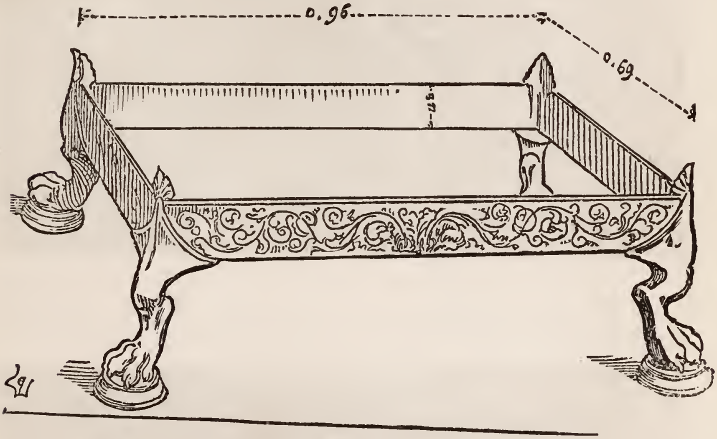


FIG. 87.—ANCIENT BRONZE FOOTSTOOL. (Museum at Naples.)

M. Majorin, leaving Jean surrounded by these curiosities to get along as well as he could, went away to take notes. He saw that his pupil was a prey to that fever for possession which seizes certain natures when they find precious information within their reach, and he avoided interrupting him until it was time to close the halls.

After dinner, in the evening, Jean showed his sketches to M. Majorin, who made many comments, but found to

Fig. 88.—Detail of an Antique Footstool.

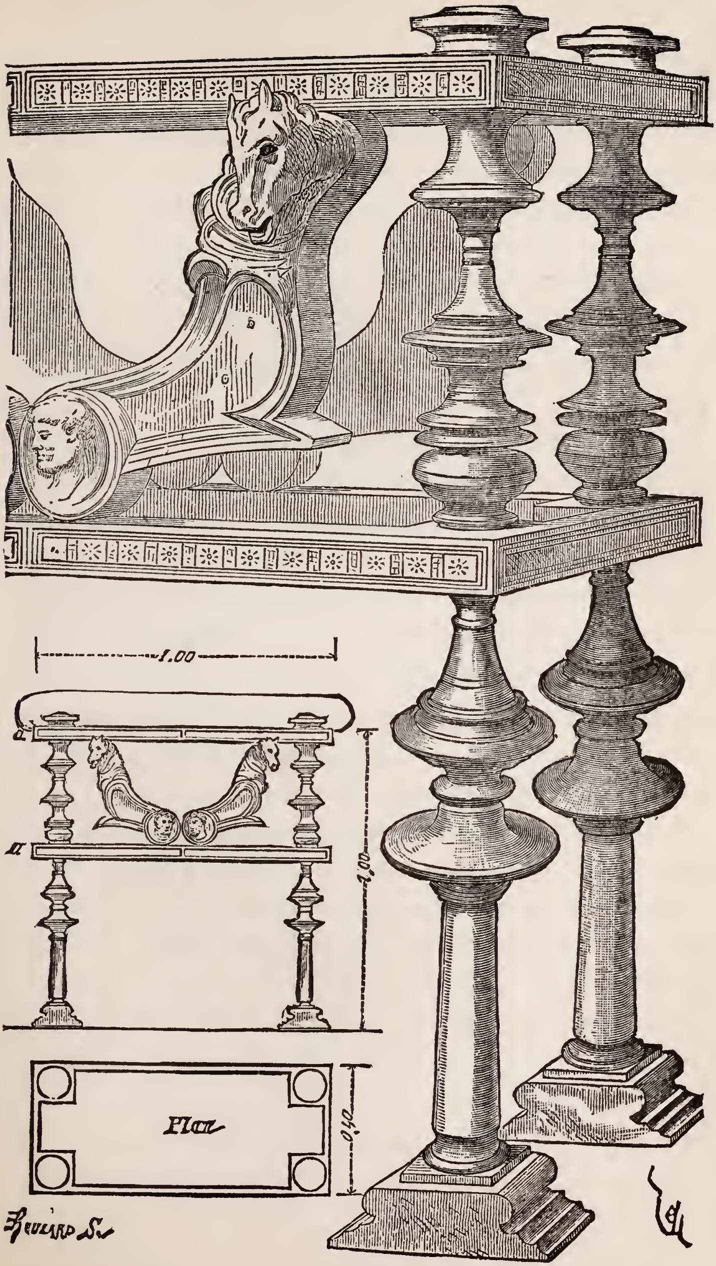


Fig. 89. — Antique Bronze Throne. (Museum at Naples.)

his delight that his method had aided the young lad; as each object was truthfully reproduced in its proper character, though in some respects there was indecision.

"You need more precision," he said to Jean. "Do not be satisfied with an approach to perfection. You must not merely draw, but also understand the object drawn, its structure, when it is rational, and the methods employed.

"Thus drawing may be useful: otherwise it is only an amusement of an amateur. We are rather disposed in France to be satisfied with what is tolerably well done, counting on our intelligence to supply the lack of observation. It is a habit to be avoided. When you are in Paris, you cannot go to the museum at Naples to examine any part omitted, or to correct an error; therefore, when you have before your eyes an object of which you wish to know the exact form and the slightest details, you must leave nothing in your study uncertain."

The next day they examined the paintings in the museum and the relics from Herculaneum and Pompeii.

With these works before him, M. Majorin was able to explain to his pupil the degree of civilization of these ancient peoples, and how much freedom and invention were manifest in what they produced. He showed Jean representations of *armoires* exactly like our own (Fig. 90); a baker's shop (Fig. 91); porticos which were sometimes closed, with low partitions with openings, and

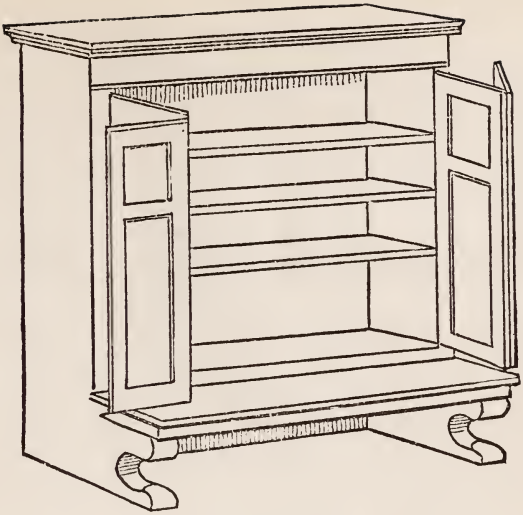


FIG. 90.—PAINTINGS AT POMPEII. AN ARMOIRE, OR CUPBOARD.

FIG. 91.—PAINTINGS AT POMPEII. BAKER'S SHOP.

Fig. 92.—Paintings at Pompeii. Closed Portico.

(Fig. 92) the charming originality of the ornaments; that painting was always called upon, the better to dis-

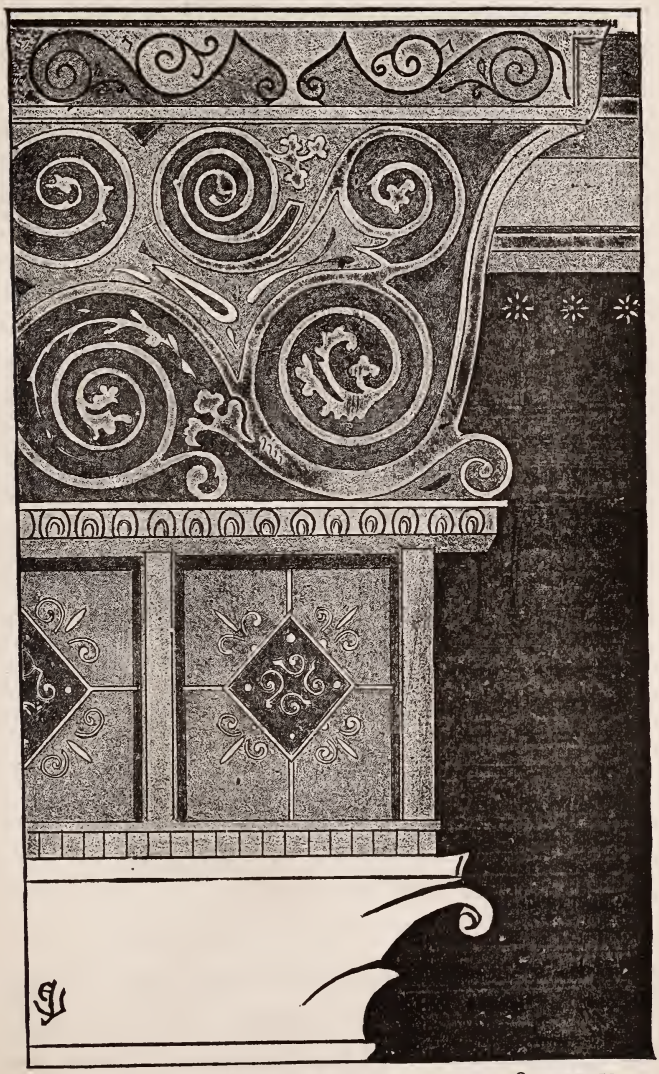


Fig. 93.—Painting from Pompeii. Architectural Ornaments.

play the architecture, and that these two arts seemed to be necessary supplements of each other (Fig. 93).

He pointed out that these Pompeians, in their gardens, made lattice-work with doors, vases (Fig. 94), little fountains, rockeries, and grass-plats like ours; and that finally,

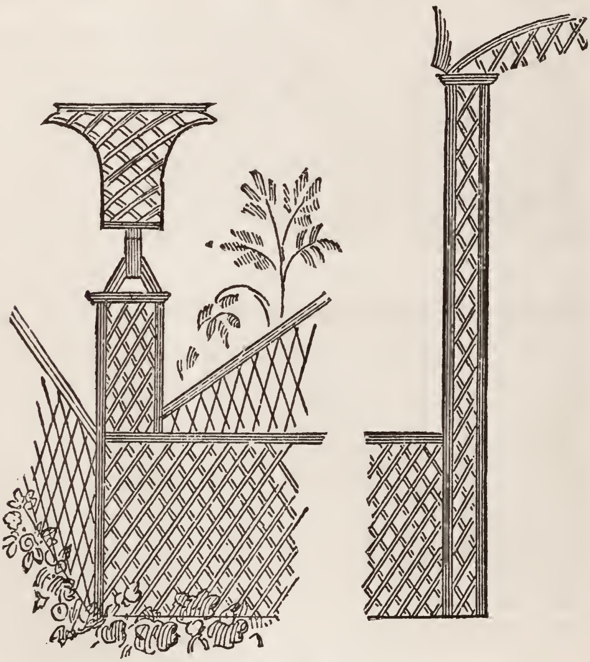


Fig. 94.—Painting from Pompeii. Lattice-work.

although there is nothing new under the sun, these Italian peoples might often regard us as barbarians, because, unlike them, we do not know how to make every

thing artistic, and have too long restricted the enjoyment of art to a few.

"But," continued M. Majorin, "do not think that ever since the fall of the Roman world it has been so. Our middle ages, often charged with barbarism, freely followed the footsteps of the ancients, and knew how to apply art to every thing. But one day an association was formed with the singular purpose of making the practice of arts a monopoly useful to itself alone. Sustained by a most despotic monarch, it assumed exclusive privileges, and declared that no good work existed previously, and before the reign of this monarch, a claim which the latter strongly approved.

"Since then, in France, where art sprang up of itself, people have undertaken to cultivate it in a hot-house, to subject it to invariable rules, and to train it according to certain methods, and to regard whatever sought to grow outside of hot-houses as weeds, and consequently as unfortunate plants that ought to be exterminated.

"Our artists became accustomed to such measures, and with the belief that they should ornament only palaces, and please those who lived in them, withdrew to that sanctuary supposed to be the proper place for them.

"Barbarism thus gradually spread among the common classes of our French society, as always happens to a people when art is looked upon as a superfluous luxury.

"The study of drawing is undertaken for mere pleas-

ure, which only people who have leisure can indulge in; which is a sorry state of public sentiment as regards the poor fellows who feel called upon to follow art.

"If, in our day, there is a re-action against these lamentable prejudices, it must not be believed that they are uprooted from the minds of the majority.

"The despotism of the seventeenth century aspired to make us, whom nature has made kinsmen of the Greeks, and who resemble them so closely in our good and bad qualities, like Romans under the empire. To return to our subject, though the wealthy Romans filled their dwellings with masterpieces taken from Greece or bought of its artists, through vanity rather than from love of art, they disdained to practise the arts and all the manual trades. These belonged to slaves or freedmen. Louis XIV., the great king who did our country so much harm that we are still forced to atone for his selfishness, vanity, and faults, wished to make art, as every intellectual emanation of the country, something all his own and dependent on the court, and to make artists a sort of aristocratic body corporate, devoted to the monarchy, and exclusive. He succeeded only too well; and art thus practised in an elevated circle became extinct among the people.

"Since that time, which was so fatal to France, when we followed in the wake of the Romans of the empire, we not only have no longer possessed a national art, but have retrograded in whatever our industry has produced.

"To the extent that the privileged class have desired a luxury unprecedented in art, regardless of the forms which necessity demands, the common people day by day have lost sensibility to art. That is why, my friend, it is well to study how this old Italian civilization, which was still Greek in its customs, learned to apply art to the most common utensils; how it produced art unconsciously, as apple-trees bear apples, because free art belonged to all, was understood by all, was necessary to all, and was not a monopoly.

"I took you at once to the centre of ancient art, that you might be convinced of this truth, and that you might learn how the form is worthy of art only when art is in harmony with nature and the use of the object to which it is applied.

"These well-attested and well-known qualities may be found in other epochs, and particularly in France before the seventeenth century. When you recognize their existence, do not heed the prejudices, the trite ideas, nor all the foolish and commonplace remarks that you will hear everywhere repeated. Study and reflect: thus you will form your judgment, and acquire the knowledge which will be useful to you, whatever career you follow."

The stay of the two friends at Naples was divided between Pompeii, Herculaneum, and the museum; and Jean gathered an ample harvest of sketches under his

teacher's directions, to whom it every day became more evident that Jean was most particularly attracted to objects which satisfied his reason, and whose value and use he readily understood.

"So much the better," thought M. Majorin: "with such a taste, in our time, the lad will be either an engineer or architect, or a manufacturer. He was not born an artist, and I am quite as well satisfied."

CHAPTER XVII.

TWELVE DAYS IN THE ALPS.

"HOWEVER," again thought M. Majorin, "who knows but the little fellow, on account of the decided bent of his mind, may become a *savant* and observer, and capable of putting his observations into practice? We will see."

They stopped three or four days in Rome, two days in Florence, and, taking the road to Milan, embarked on the Lake of Como to descend to Colico-Piano, and to ascend by Chiavenna to the pass of the Splügen, in order to reach the valley of the Vorder-Rhein by the Via-Mala and Tusis, then Interlaken by Ilanz, Dissentis, the Ober-Alps, Andermatt, the Furka, Grimsel, Handeck, Hoff, Grindelwald, and Lauterbrunnen.

It is useless to repeat Jean's exclamations of astonishment during this trip, made almost entirely on foot, with their bags on their backs. It is of consequence only to know what advantage it was to our young man. M.

Majorin was provided with the geological map of Switzerland, drawn by Studer, and took pains to show him on the spot the changes in the ground and the character of the upheavals in that part of the Alps. But the explanations which most interested Jean were those relating to the successive changes which these upheavals had undergone on account of the presence of glaciers, of their successive meltings, of the action of water, and the decomposition produced by atmospheric phenomena. M. Majorin never discussed these subjects at length; and his explanations only provoked new questions from his pupil, which were not always easy to be answered.

After they left Camerlata, and before embarking on the Lake of Como, M. Majorin pointed out to Jean the moraines, heaps of stones and sand brought there by the ice which filled the lake during the glacial period.

He was obliged to tell him what the glacial period was. Naturally Jean asked why ice had been accumulating on the Alpine range for thousands of years. M. Majorin did not answer, except that the fact is undeniable, because the ice left everywhere the marks which it still leaves to-day on the rocks in the path of the glaciers, and because of these moraines which are composed of the *débris* of the summits and declivities. This glacier epoch was divided into two periods, separated by an interval during which vegetation developed nearly as it does to-day. Then M. Majorin pointed out on the maps the principal

currents of this ice, descending from the summits to the plains as far as Camerlata, at the end of the Lake of Como; below Arona, at the end of Lake Maggiore; to Bornato, at the end of Lake Iseo, and near Lyons below the Lake of Geneva. Jean asked if there were men in the plains at that time.

"It is probable," answered M. Majorin. "It is certain that their presence is discovered in the deposits made by the inundations in consequence of the melting of the ice. The climate of France was almost like that of Iceland itself, in which men could live if the days and nights were only divided as they are now."

Jean asked why the temperature was so cold, since the sun must have had the same power then as to-day. M. Majorin replied that many theories had been formed on this subject, but none appeared satisfactory; that, in the study of sciences, it was for a long time necessary to content one's self with collecting the records of exact and accurate observations before drawing any conclusions; that, during the glacial period, the sea bathed the foot of the Italian Alps, inasmuch as a number of marine shells were found attached to the foot of the moraines at this end of the glaciers.

Afterwards, while ascending the lake, M. Majorin showed his pupil, on the sides of the mountains which incased it, the marks of the passage of the ice and the characteristic snow-white rocks which he soon saw close by on the very borders of the real glaciers.

Indeed, when the travellers ascended the valley of San Giacomo, in the midst of very extensive slides of gneiss, which are again seen below Campo-Dolcino, M. Majorin pointed out to Jean these rocks that were worn and striated by the ice, then the little lakes filled one after the other by the muddy streams resulting from the melting of the ice. And he did not fail to require his young companion to take notes, and sketch, and to draw a topographical map on the spot, the better to understand the lay of the ground. He explained how these valleys, which were composed of hollows and obstructions, had gradually been levelled by these torrents.

"In time," he said, "these lakes which you still see on the map, the lakes of Thunn and Brienz for example, will be filled with these sands and pebbles borne along by the torrents when the snow melts.

"Formerly there were in each valley chains of these lakes, which were successively filled up, and formed these cultivated terraces. The torrents have thus regulated their course, and formed the banks between which they run."

This greatly astonished Jean, although he had some difficulty in understanding, amid this apparent disorder, the phenomena which M. Majorin explained. But, as they approached the pass of the Splügen, the explanations seemed clearer, and his eyes were no longer distracted by the verdure, land-slides, and the thousand accidents of valleys.

These vast arid solitudes make very different impressions on travellers who visit them. Some declare these deserts in which nature seems desolate and in ruins frightful, and desire to fly from them as quickly as possible; others find an indefinable charm in these lofty heights, and leave them with regret. M. Majorin, according to his habit, took pains not to create in his pupil one or the other of these impressions by a previous description. But when the travellers had passed the Italian custom-house, and ascended the road which leads to the pass, where no trace of vegetation appears, and where patches of snow spread out between gray decomposed rocks, M. Majorin watched the face of Jean, who, although the journey had been long, was hurrying on to reach the pass more quickly. His face lighted up with eagerness to reach one of these patches of snow which he wished to see and to touch. It was strange to have snow in August, under a dazzling sky and the heat at twenty-five degrees. They seated themselves in the pass.

"How pleasant it is here," said Jean, "and how beautiful this silence!"

Then M. Majorin explained to him, from this place of observation, the movement of the ice as it descended from the summits to the valleys; and he made him touch the rocks that were polished and striated by its passage, and showed him how these summits were decomposed every day to fill the valleys and fertilize the plains.

"We must descend to the village of Splügen," he said after an hour's talk: "it is late, and we have still a long journey."

"It is a pity to go down so soon," responded Jean, "we are so comfortable here!"

M. Majorin, who had a strong love of mountains, but who never expressed how charming solitude was to him, knowing that such feelings are rarely understood, was secretly delighted at finding that his pupil shared them; and as he descended he said, —

"It was not until science revealed to man the mysteries of nature, that he began to travel through the mountains with a desire to know them, and that he acquired a passion for the grand views from mountainous heights. Primitive man feared them, and looked upon them as the abode of divinities, who were, after all, only personifications of the forces of nature.

"From these summits tempests arose, and destructive torrents and fertilizing rivers descended. In serene days, these elevated peaks, covered with snow, and purpled with the rays of the setting sun, with their shadows blending with the azure of heaven, might pass for celestial abodes.

"These innocent beliefs in a measure approached reality; indeed, the mountains were the laboratory where was formed the territory which — intersected by winding rivers — we now cultivate, and on which we build our

cities; and this process of forming new territory is still going on. The labor was vast, extremely protracted, and marked by a thousand accidents which still happen, though of less importance.

"For centuries men thought these upheavals only a frightful confusion, and an inextricable chaos: they crossed them with extreme reluctance; and among the writers of the last centuries one finds no trace of admiration for the scenery of these heights.

"It was necessary that science should intervene, and introduce a knowledge of geology, and give some insight into nature's work on the mountain-chains, that one could behold their grandeur more closely, and, as it were, with new eyes. One acquires a passion for these sights, even to risking his life a hundred times to discover some of the mysteries of matter. To those who study them, mountains are no longer the abode of divinities, but of what we call inorganic matter, which takes part in the grand, endless labor of decomposition, transformation, trituration, elimination, motion, evaporation, and condensation, and furnishes the earth with the water of its streams and rivers, fertilizers for the plains, local currents of air and healthfulness to the low valleys which we inhabit, and also the resinous woods, which we could not do without, and fields for innumerable flocks. This apparently chaotic matter is thus nature's great nurse; and these barren solitudes, covered with snow and ice,

are, as I have said before, the laboratory where are manufactured the elements of our fertile fields, and the beautiful gardens of our plains.

"Yet the height of these summits is growing less every hour; the stone which crumbles away, and rolls into the ravine, and the dust which the wind bears away, never ascend again. The torrents sweep away this *débris* into the low valleys, which are thus raised; and some day only scattered ruins of these lofty mountains will remain. Then there will be no more glaciers where in winter the summer supply for the rivers accumulates, and no collections of vapor to dissolve into rain when heated.

"The rocky or arid steppe will replace our green fields."

"Will this really happen, sir?"

"Oh, do not be alarmed! it will not happen very soon, but must inevitably happen some day."

"And what will then take place?"

"The human race and animals will gradually disappear from the earth, because it will be unable to support life, as they have disappeared on several parts of our globe where, within the historical period, similar phenomena have occurred."

This conclusion might have saddened Jean; and, fearful that he might contribute to the destruction of the mountain, he might have taken care not to roll down a pebble into the valley with his foot, had he not begun to be ter-

ribly hungry; and, when the stomach is empty, one is little disposed to lament the end of the world, which may take place some thousand millions of centuries hence.

After a good supper and a comfortable night at the village of Splügen, our travellers were ready to start again. Early in the morning they ascended above the village, and Jean drew the Point of Ucello, which is composed of mica-slate.

"Oh, stop!" said M. Majorin, while Jean was sketching: "you are too free with those rocks, which require to be drawn with great exactness, for their forms are not due to chance. There are prominent principal lines which you must first indicate; then, when they are faithfully outlined, omitting none of the angles and inclinations, you must fill in the details according to their importance (Fig. 95), otherwise you will give details and accidents an exaggerated value on account of their distinctness. Those who are acquainted with mountains see at once when a drawing is carelessly executed, or when it is carefully studied: each kind of rocks has its own form, and it must no more be neglected than the features of a face or the lines of a plant."

But when, after passing Ander, the travellers entered Via-Mala, Jean was filled with wonder. The road extends down a fissure of the mountain, by the side of a torrent which it crosses several times; and, as it is cut out of a perpendicular rock, one at times can hardly see the sky.

Fig. 95.—The Point of Ucello at Splügen.

At one point, where this immense crack enlarges a little, M. Majorin described how the glacier, which descended the valley of Ander, forced a passage by widening the upper parts of the walls, and by wearing them away and rounding them, while it left the narrow parts of the cleft free to serve as a basin for its torrent, so that to-day a section of this valley of Via-Mala gives the outline in Fig. 96. The glacier filled all the space A, while

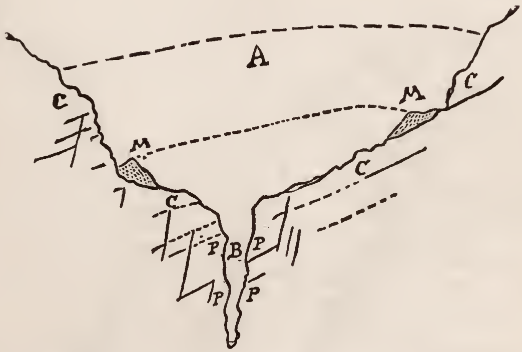


FIG. 96.—SECTION OF THE GORGES OF VIA-MALA.

the crack B was empty, and served as an outlet to the melted snow. And, at the walls C, the passage of the glacier is marked by the wear of the rocks, and even by the deposits of lateral moraines at M when the glacier slid down; while the walls, P, show sharp, distinct breaks, not at all rounded by the friction of the ice.

"That," said M. Majorin, "is because the ice, though plastic, does not run like water; but forms an elastic

body, which contracts or expands according to the arrangement of the walls between which it moves, but it does not mould the fissures. Look above, and you see the ice has removed and worn out the rock against which it has rubbed for centuries, so that it looks like a tower; but below it has not touched the sharp breaks which still

FIG. 97.—FRICTION OF GLACIERS ON THE ROCKS.

appear in that deep portion, while it has worn the projecting walls B (Fig. 97), and so much so, that, if following a horizontal section we imagine these rocks at O, we shall thus have proof that the ice bore heavily at D, projecting parts. The direction of its course being shown by the arrow, it hardly touched the wall E, and left a gap

at V, because, at this point, the rock was not polished by its passage.

"Moreover, we observe this same phenomenon in the glaciers of to-day. You see nothing in these forms, which at first appear so irregular, that is unimportant or due to chance; and, if one wishes to reproduce them for study, he must pay attention to the slightest accidents which explain the successive changes through which these various

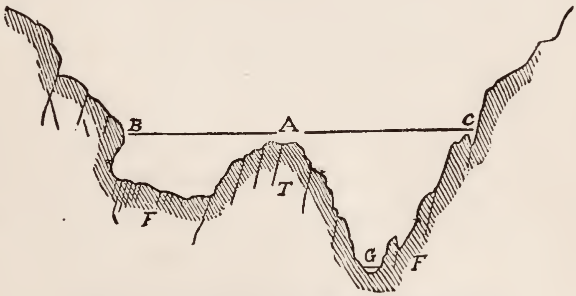


Fig. 98.—The Val de Barberine: Sête-Noire.

upheavals have passed. Thus, I remember having noticed in the Valorsine Valley, between Châtalard and Salvan, very high landmarks composed of schist left by the glacier, which then descended to the valley of the Rhone; in the middle of this valley these landmarks form islets, as seen in Fig. 98.

"During the glacial period, the stream of ice filled the whole of this valley; and if the landmarks, T, resisted its action, it was because they are composed of veins of rock

much harder than those at T. Now, to-day the torrent runs at G, and rounded pebbles are found only on its sides. However, at A, on the crest of these landmarks, there are many of them; and, as they were not brought by the eagles, the torrent must have filled the valley from B to C. The violence of its current has for a long time carried lower all the pebbles deposited between the walls of the valley and the landmarks; but the pebbles which fell at A remained in place, and they prove that this glacial torrent rose at least to the level A.

"You see, I repeat, that in the study of these mountains every thing is important; and nothing should be neglected if one wishes to understand any thing by the forms of to-day; and that, when one draws them — other than as a simple but ignorant lover of nature, — not a detail must be omitted, and nothing can be left undecided."

Profiting by this advice, Jean began to carefully copy the mountains; which gave him an opportunity to learn that there are general laws governing their form, and even the manner in which they crumble away, and that a certain arrangement invariably leads to a certain fact.

After a few days, he could determine very well the nature of the rocks. But the sight of the glaciers of the Rhone made him easily understand, with the help of M. Majorin's explanations, the conditions by which those masses of ice were governed, and their downward movement. But he did not have a correct idea how these

mountains were upheaved until his trip from Grosse-Scheidegg to Wengern-Alp.

On this journey they followed the Oberland chain, which rises like a rampart of crystalline rock piercing a lofty group of the Jura Mountains. At the station of the Little Scheidegg, looking at a map and nature spread out before him, M. Majorin gave the following explanation to his pupil by the aid of a sketch (Fig. 99) : —

" Suppose a cut to be made from the north to the south,

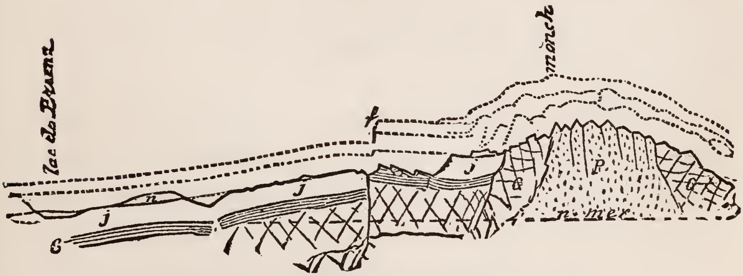


FIG. 99. — THE UPHEAVAL OF THE OBERLAND CHAIN.

that is to say, from the lake of Brienz to the Monch, a peak at the north-east of the Jungfrau. The right shore of the lake of Brienz is bordered by the Neocomian strata, while from the left shore emerge the Jurassic formations marked by a *j*. There remains at some distance from the lake a strip of the Neocomian strata at *n*, then the Jurassic formation continues to rise to where we stand. There is a rent; and in spots appears the schist which extends under a formidable escarpment of the Jurassic

formation, which remains fixed while the schist above it appears at the rent.

"This Jurassic formation has been pierced by the gneiss *g*, which has been raised and pierced by the volcanic rock called the protogine. But you can understand that this gneiss and protogine in bursting the crust have raised the strata of schist, lias, the Jurassic formation, the Neocomian strata, and the upper sedimentary rock which I show you by dotted lines. It is the ice, then the waters, which carry away all that part near the dotted line, leaving only this bit of the Neocomian strata and parts of the Jurassic.

"These upper layers have thus been eliminated, because they were weaker and greatly broken up by the upheaval, especially at the prominent points. See how the formations around us have been polished and eaten away; so that if the ice did not hollow the valleys, as some geologists have claimed, at least they have cleared away at first all the parts that were raised and broken up by the upheaval, driving them before them, or carrying them on the back of the glaciers.

"The large bed of snow which formed on the Jungfrau and the Eiger here before us, and on the Wetterhorn which you see on the other side of Grindelwald towards the east, has gradually worn away the steep side of the rent *f*, and left only the still quite large piece which rises along the chain, and which is marked in this section, but which is being destroyed every day.

"Yesterday you made a sketch at Grindelwald, which shows very well how the glaciers continue to cut the remainder of this uplifted Jurassic formation (Fig. 100).

FIG. 100.—THE BASE OF THE GLACIER OF THE LOWER GRINDELWALD.

The lower Grindelwald acts, or at least has acted, in this escarpment like a chisel; as is indicated by the swell at the bottom of which it descends, now very much diminished."

"But, sir, this rock which you call protogine, and which, you say, is thrown up by volcanic action, does not resemble the lava which we have seen in the Auvergne and Vesuvius."

"No: protogine and granite (for protogine differs but little from granite) made their appearance long before volcanoes, and the granite or protogine was not poured out like melted lava. This matter was not in an incandescent state, but was like paste at a very high temperature, and had not the flexibility of the lava, whose chemical composition differs but little from this granite. These granite pastes, which contain principally feldspar and quartz, have not, like the lava, extended along the upheavals they cause; but have crystallized on account of growing cold very slowly, while the lava, which cools rapidly, remains in an amorphous state, like melted iron from a blast-furnace."

"But why did it not come forth then as now?"

"I cannot answer that satisfactorily, my dear. It is a fact proved by observation, that volcanoes originated within a comparatively recent period. Perhaps it is because the crust of the earth has acquired greater thickness and solidity, and because the melted matter in the earth no longer finds a way to escape except through craters, in consequence of the contraction of the crust above it by cooling. However, if you look at a map of the volcanoes of the earth you will notice that they are

located according to certain continuous lines or cracks in the crust. The same phenomena may be seen more clearly when you look at the moon through a telescope. The vast craters of this satellite form real chains, following rectilinear fissures which furrow the lunar sphere."

"How can one know that volcanoes are of a comparatively recent origin?"

"That is easy to prove. After the first film of the

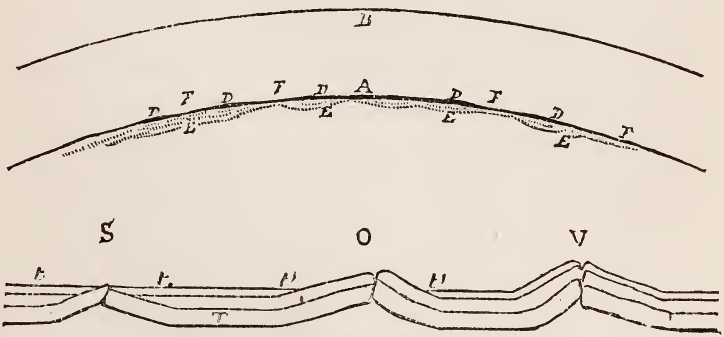


FIG. 101.—COOLING OF THE EARTH'S CRUST AND SEDIMENTARY ROCKS.

earth became cold (which first occurred with the most refractory matter, with mica for example), the crust thickened in two ways; first, by the gradual cooling of the matter in fusion beneath it; second, by the deposit of material held in suspension, on account of its comparative lightness, in a strangely charged atmosphere; so that the atmosphere (Fig. 101), A B, became separated from the nucleus by the matter D, which no longer had heat

enough to remain in fusion, or in a gaseous state. When the separation was once made, the heat of the nucleus radiated less into this atmosphere. Gradually this first film thickened at E or beneath its external surface, and the heaviest material suspended in the atmosphere was deposited at F, on this first film, in successive layers, which are the rocks with whose position you are familiar. If there is a rent and an upheaval after the deposit of the primary rock T, as I have marked at S, the rest of the rocky material deposited afterwards was laid horizontally along the first upheaval, as I have indicated at *t*. Though it was after the formation of the secondary rocks that the upheaval took place, as you see at O, the tertiary rocks rested horizontally on the slope of this upheaval as is outlined at *t*. And if it happens that the tertiary is lifted as at V, it indicates, without doubt, that the upheaval took place after the formation of the tertiary rocks deposited by the waters, and, of course, in the first place in horizontal layers. Then, by examining the upheavals and the disturbances of the different strata of the globe, one can ascertain their relative ages. These volcanoes being upheavals which have disturbed the uppermost strata of those just below them, one can conclude that they were last in point of time.

"When I say upheaval, I make use of the conventional term; but the word 'depression' would be more exact. Follow this attentively. When a body becomes cold,

it loses some of its bulk, and contracts. Now, the earth, when its first film became cold, and was finally separated from the atmosphere, was necessarily rather thicker than to-day, when this cooling has reduced its bulk. It is true, on the other hand, that the rock material in suspension in

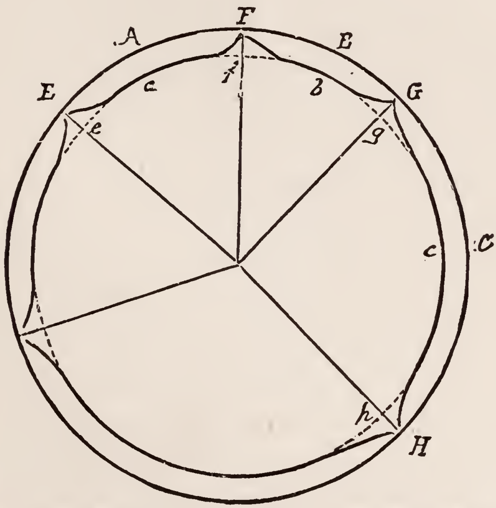


Fig. 102.—Mode of raising and depressing the Crust of the Earth.

the atmosphere, and deposited on this first film, has enlarged the primitive crust. However that may be, the sphere of the earth has contracted.

"If, then (Fig. 102), the section of the first crust of the earth is the circumference A B C, &c., and if the bulk of the globe has contracted on account of being cooled as far as the circumference *a b c*, &c., it is clear

that the segments, E F, F G, G H, cannot be contained in the lengths *e f*, *f g*, *g h*, and that if the surfaces A, B, C, follow the reduction of the nucleus to *a b c*, there must be seams, fractures, and rents as indicated by the diagram (Fig. 102), so that one may no more say that the mountains are raised than that the plains are depressed."

"I understand," said Jean; "but this central nucleus of the earth, in an incandescent state, is not composed of the same rocks as it was in the period of the eruption of granite and porphyry?"

"The question is indeed embarrassing; yet supposing the nucleus to be really in a state of fusion, one can admit that the upper strata, which have surged to the surface of the globe after its first stage of cooling, were the lightest; but, being cooled in their turn, the matter underneath, which was still in an incandescent state, may have differed from the former in its composition, and contained iron, for example, which did not form a part of the matter first poured forth."

"You say, sir, 'supposing the nucleus to be really in a state of fusion:' is there any doubt of it? In the course of geology which I have followed, this fact was admitted as certain."

"In science, only that which can be proved by direct observation is certain. Now, as no one has been able to see or penetrate this burning central nucleus, it cannot be affirmed that it exists. The deeper one digs in the

ground vertically, the greater the heat, so that it is necessary to ventilate very deep mines, where, in spite of thorough ventilation, it is very warm; then all the volcanoes pour forth streams of lava which are very much alike; but we have only presumptive, not certain, evidence of this phenomena.

"It is sometimes annoying to be unable to affirm, affirmation being convenient for promptly establishing a theory; but we should avoid affirmations when direct observation has not proved a fact. I can affirm that the upheaval of the Alps has occurred since the formation of the territory of the Jura Mountains, because the one has overthrown and dislodged the other, for I see it. But I have not seen the incandescent nucleus of the earth, and the lava which seems to come from it is not a sufficient proof, for lava may be produced in other ways, as by local, subterranean, chemical combinations: the filtering of water into the subterranean strata, for example, may produce chemical action, and certainly produces vapor. Now, you will observe that all the volcanoes of the earth are not far from the sea or from very large lakes, and that all the eruptions emit vapor in a large quantity. Water, then, plays an important part in volcanic action. Science does not advance through doubt, though one must doubt when science does not prove."

Thus, on every occasion, M. Majorin knew how to

interest his pupil in all that he saw, and developed in him the desire to learn, thinking that all kinds of knowledge

Fig. 103.—Valley of Lauterbrunnen.

are connected, and that if one is to follow a specialty it is an error of judgment to exercise the mind in only one branch of study.

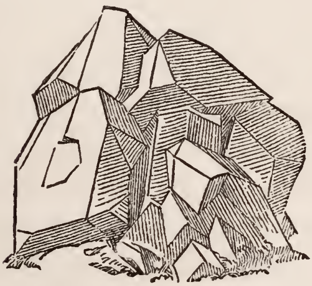
On descending Wengern-Alp to Lauterbrunnen, M. Majorin showed Jean the bed of the glacier, which, running from the Jungfrau to Interlaken, filled the valley, which he wished him to sketch (Fig. 103); and showed him how the glacier had worn away the sides of the mountains at *a*, and deposited moraines along them.

The next day, from the station of Heimwehfluh above Matten, M. Majorin made Jean carefully draw the Jungfrau and the Jung-Fraujoch, whose crystalline rocks are so sharply defined, and present so characteristic a formation (Fig. 104). The frozen snows show the great crystalline rhombs, subdivided into little rhombs, which enables one to estimate the destroyed parts and the depression of these summits, whose height, originally greater, without counting the *débris* of the upheaved ground, must accumulate vast quantities of snow, and thus contribute to the formation of glaciers.

This journey, during which Jean had seen so many different things, at first only confused his thoughts; but soon, owing to the notes taken by M. Majorin's advice, and the sketches collected, a certain light burst through this chaos, and the works of man seemed to attract him even more than the study of natural phenomena. When he returned to Hay, he therefore prepared to enter the Central School; and, following M. Majorin's advice, began to draw from the living model.

FIG. 104.—THE JUNG-FRAUJOCH.

"For," said his teacher, "whoever knows how to draw must be able to model; and, when one perfectly conceives a form, it is no more difficult to render it by the aid of the chisel than by a pencil: one must therefore accustom himself to freely use either."



CHAPTER XVIII.

SYNTHESIS.

THAT readiness in observing with benefit, and in determining the result of his observations, which the habit of drawing gave Jean, was of great help to him, not only in his examination, but in following his studies. He was soon distinguished among his fellow-pupils at the Central School by the intelligence shown in his work, and the promptness with which he understood and answered questions. M. Majorin watched his pupil's progress with increasing interest, and congratulated himself on having early given him the habit of accurately comprehending every thing agreeably to the scientific method, and having taught him never to be content with what he had accomplished, or with the pedantic phrases lavished by the majority of those who, without practising the arts, aim either to teach them, or to plunge into dissertations which are as vague as they are useless.

With the study of drawing and the knowledge acquired

by it, M. Majorin had furnished his pupil with that which would aid him in any career he might follow, even were it foreign to what is properly called art. This was as he wished; therefore, when Jean left college with the highest rank, M. Majorin sought that kind of employment for him where his knowledge would be the most serviceable.

M. Majorin, in his intercourse with numerous manufacturers of the so-called Parisian products had often expressed the opinion, that, as foreign competition was tending every day to advantageously compete with home production, it was necessary to give the production in which above all others Paris excelled, a new impulse, — to elevate it above the commonplace.

"We produce," he said, "works of art which have great value, and are rightly appreciated, either for their composition or their execution, as they deserve to be; but together with these exceptional works, which are consequently dear, we give the public at a low price a number of common articles which can be recommended neither for taste, invention, nor convenience. Now, it would not cost much to adopt forms that are proper, and that please, and are perfectly appropriate to the object. With the aid of our instinctive faculties, we may thus acquire an indisputable superiority over our competitors. We have long possessed it; and why should we lose it, or why should we not try to victoriously regain it? For centuries, articles, furniture, and utensils of French manu-

facture served as models, and were distributed everywhere. To-day, though we have not wholly lost the favor of foreigners, we cannot hide the fact that great efforts have been made to deprive us of it, or to do without our products. Museums, schools, and systems of education are springing up everywhere around us; so that if we had not taken good care of what was left of our national genius, though every thing has been done in our land to suppress it, it would long ago have been extinguished.

"It is time, then, to foresee the danger, and to regain the place which we should never have allowed to be taken from us. Let us not wait for the help of the government, who care nothing about it; for our statesmen are unacquainted with such matters. If they love or cherish the arts, it is in a more or less academical or capricious way; but they do not attach to their protection or love a national benefit. If they pay a high price for a charming piece of carved furniture from one of our best manufactories, they do not trouble themselves to inquire if the furniture of the humbler citizen is in execrable taste, or the tools of the workman are of an ungraceful and inconvenient form: they think they have sufficiently proved their position as protectors of the arts by surrounding themselves with costly trifles.

"I know beforehand what you are going to answer. The taste is acquired, and one runs some risk in trying to reform it. The *bourgeois* will prefer furniture in ugly

white wood, veneered with violet ebony, or mahogany of a style sanctioned by custom, although it may be awkward and unsightly, to that which is of the same price and well made, and with a proper and pleasing form.

"We bear the expense of manufacture, and yet cannot sell. There is reason for objection; but beware. It may happen, that, without any one foreseeing a return of public taste to more sensible and in every respect better works, this taste may of itself be reformed, and demand from abroad the articles which you will not have manufactured in season. Already Germany — Hanover, for example, — makes furniture, which, if it has not the grace of our own when we are willing to take the trouble to give it, is at least sensibly designed, simply executed, and consequently cheap, and of a form manifestly more fit for use than the greater part of what we manufacture. England, which of late has bought furniture in France, is beginning to offer work which in many respects is superior to that which we commonly produce. This now happens rarely; but, in a few years, the English will in their turn have succeeded in manufacturing such articles at a low price; and, being less inclined than ourselves to follow routine, will flood our country and the world with their goods.

"Little as fashion may have to do with it, all those old styles which you all the time reproduce under the pretext of making a Louis XIII., Louis XIV., Louis XV., and Louis XVI., and all the Louis, which have but little

relation to our customs and habits, will remain in your stores. It is not sufficient to state in speeches, that, *though the star* of France *is paling*, rising generations will restore its brilliancy: to accomplish this, something more than words is necessary. Yet I notice, that, high or low, we are all the time talking, and seldom doing."

These reasons, and many others which we omit rather than to say too much on the subject, made a certain impression on the friends of M. Majorin; and after several consultations it was resolved: first, that they would try to found a school in which all these questions concerning furniture and household-utensils, and referring to what is improperly called *the industrial art*, should be taught, not by furnishing pupils a number of objects collected from everywhere without critical examination, but by bringing out the principles which ought to be followed in the manufacture of these various articles according to their use and the character of the material to be employed; second, that to this school they would add workshops where the instruction given would be put in practice.

A few men with original ideas (and there are still some among us) even offer to furnish new principles, such, for example, as the union and appropriate use of wood and iron in delicate carpentry and furniture; in pottery, models such as the highest education may require; in metals, experiments with enamel at high and low prices, and new combinations deduced from the properties of these metals, &c.

M. Majorin thought that his pupil, on account of his studies having been directed, carefully freed of routine, because of the ease he had acquired in drawing every thing, and in understanding nature and the use of every object, was very well fitted to enter an institution of this kind. But he must acquire the habit of composing; for till now he had been satisfied with merely collecting and analyzing material.

In this, as in the study of drawing, M. Majorin prided himself on having a method, though he certainly was not an artist.

"Composition," he said, "should have its laws, or it would be only a fancy and a caprice. Now, without considering what concerns painting, sculpture, and music (although it may be possible, it seems to me, to define the rules which ought to enter into the compositions of musicians, sculptors, and painters, in the matter of arts applied to architecture and various industries), it is evident that composition should have reference to two elements, — the material made use of, and the processes that can be applied to it. The composition of a work requiring melted, wrought, or forged metal, would not suit one which employs wood, marble, stone, or terra-cotta. Each industry or each process of manufacturing ought necessarily to possess a method of composition which shall be appropriate to the material made use of in it, and to the manner in which it is worked. The beautiful examples

of past centuries, which we admire, follow these elementary principles.

"To teach composition, you must first define these principles. The mistake in the instruction given in our schools has been in always presenting works that are indisputably beautiful to the pupils, without ever indicating to what they are applied, of what material they are made, and what are the processes employed by the artists or artisans who produced them, and what is their place and purpose.

"Thus it happens, that, in the majority of our productions belonging to what is called *industrial art*, the most singular transpositions are brought to the attention.

"In these matters, the want of a good education causes the reproduction in wood of works which belong more particularly to molten metal; and, in marble or stone, of forms belonging to stucco. In the composition of whatever relates to architecture and common articles, such as furniture, utensils, jewels, and gold and silver work, the first condition is to notice the particular properties in the material employed, and the mode of employing it, or the way it can be manufactured. For want of observation of these principles, one produces works that not only violate the most simple rules of good sense, but do not please, and offend reason as well as taste, and which weary with their monotony. The charm of the best works of antiquity lies in their variety of form, — the

result of the nature of the material employed, and the way it is treated.

"A tripod or a table of antique marble differs very much in appearance from one made of bronze or wood.

"The first condition of composition is a knowledge of materials and their proper manufacture."

It was necessary, then, that M. Majorin should begin by acquainting his pupil with the proper processes belonging to each of the manufactures in which he would be engaged. The task was more difficult, because there was no regular system in the workshops, and the original designers, who furnished designs to them, paid little attention to the methods suitable to each kind of manufactured article.

The majority are even ignorant of the processes, and the properties of the materials employed; and, stranger still, the manufacturers accept such compositions, and do not shrink from the difficulties, often insurmountable and always onerous, which their acceptance imposes.

Excepting in the case of wall-papers, for which are given designs perfectly in keeping with their style of manufacture (this industry is one of the best-supported in Paris), and made by artists of merit, perfectly familiar with the processes employed and their capacity for development, one may confidently assert that the majority of art industries are content to manufacture according to designs which are in no way appropriate to the object,

when the expense may be greater than the result obtained is worth. M. Majorin therefore made his pupil pass through a certain number of workshops, not so much for him to see what was made in them as to have him learn the processes belonging to each manufacture in such a manner, that, after the visits, he could ask Jean to tell him what he had seen, and convince him why these processes, and the material employed, required one form rather than another. He would then require him to draw designs according to these principles, or correct those which he had seen applied.

They often went to the Louvre, and to the Museum of Cluny; and M. Majorin pointed out in these collections the objects which best fulfilled the conditions required by the material, by its use and mode of manufacture, and with little difficulty proved that they were always the most charming.

They often visited factories to examine machinery; and M. Majorin explained to Jean why the engines in which each piece possessed the power necessary for its function, and a scientifically correct form, are the best to perform work, and the most pleasing to the eye.

"It should not seem strange to you," he said, "that the same people who know so well how to give grace to a machine by adopting exactly the form suitable to each organ erred so greatly in judgment and taste in the manufacture of furniture, utensils, and articles which are in

daily use. For machinery, being of recent invention, does not follow any so-called tradition. It was necessary to create it in every part according to new ideas; and good sense caused forms to be immediately adopted which were perfectly appropriate. But as regards a table, armoire, or clock, it is quite different: the mind is haunted by a thousand previous examples; and instead of making them in the best way and under the most reasonable conditions,

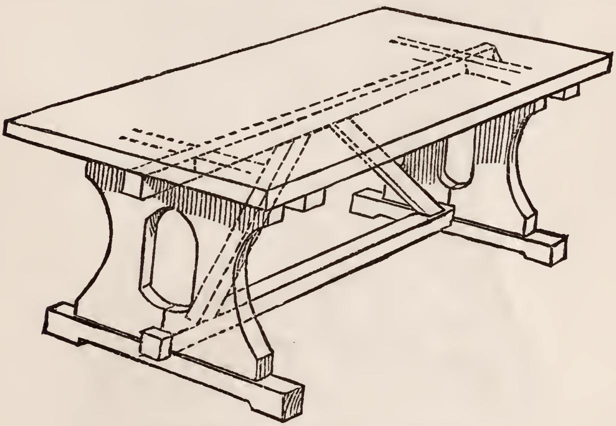


FIG. 105.—COMPOSITION: A TABLE.

as one makes a machine, by taking into consideration the material and the duty required, one thinks of the furniture of Louis XVI. or that of Marie Antoinette, Louis XIV., or of the Renaissance, and an imitation is produced which will certainly go out of fashion, and be consigned to the garret as being too ridiculous an object to be shown."

M. Majorin practised his pupil in designing, but required him first to construct the object according to the material employed, and the purpose for which it was intended. If it were a table, for example, Jean must design its correct form (Fig. 105); then, taking one of

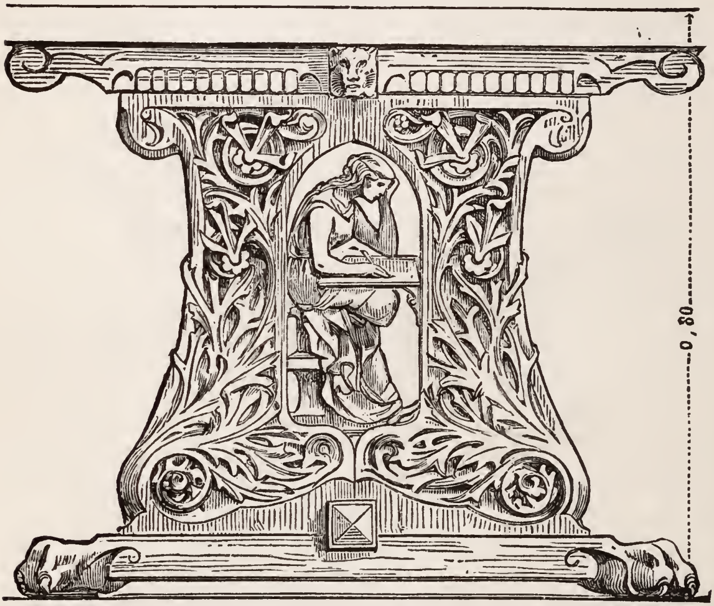


FIG. 106.—DECORATIVE DETAIL OF THE FOOT OF A TABLE.

the feet, the pupil tried to ornament it as its material and use required (Fig. 106). If it were doors, the structure must be understood beforehand, in order to secure strength and durability while giving the panels only the width of a plank (Fig. 107).

Then they added the ornaments, avoiding whatever might diminish the strength of the united parts (Fig. 108).

Thus the teacher explained how it was well to leave the wood open at the right of the mortises, so that the panels might be free to enter the grooves between them; how sculpture which ornaments panels should contribute to strengthen them in their central, and especially their lower parts; how, in order to give more firmness to the cross-beams, they should be made thick, and thus a chance for ornament be secured; how it was necessary to provide places for the locks, that they might be properly fitted; how it was necessary to outline the mouldings, according to the grain of the wood, and carefully observe the very exact laws of proportion belonging to every piece of carpentry.

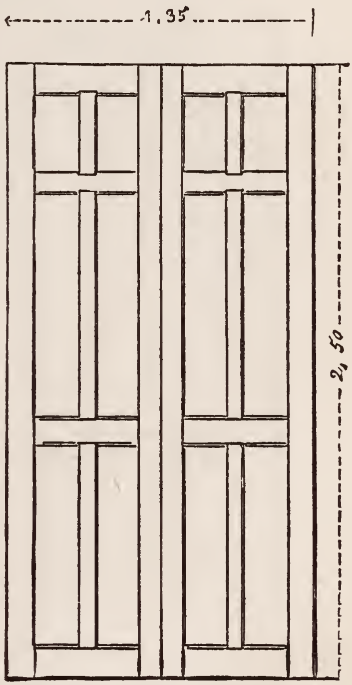


FIG. 107.—DESIGN OF DOOR-PANEL.

In regard to carpentery, M. Majorin said,—

"There is not an art or trade in which the rules of com-

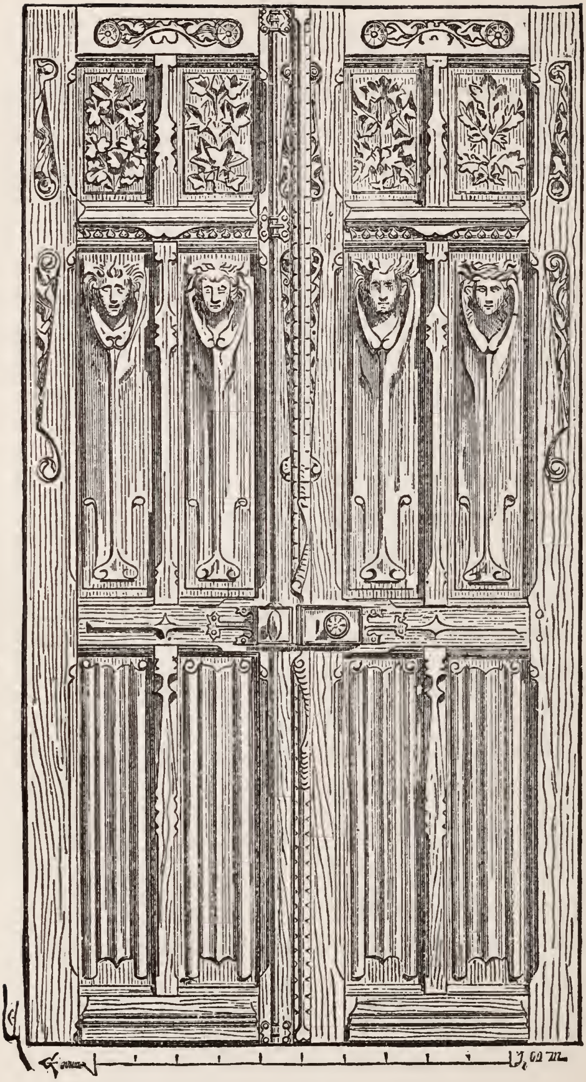


Fig. 108. — Ornamented Parts of Door-Panels.

mon-sense have been more disregarded. And yet wood is a material whose properties absolutely demand certain forms and a certain use. All wood is liable to swell and contract as the air is moist or dry, but in only one direction, — transversely; for longitudinally the fibres of the wood neither lengthen nor shorten, though they expand or contract on account of dryness or dampness. It is therefore necessary to leave the wood to a certain extent free in a transversal direction, and to avoid the use of broad panels, for example, which are composed of several boards joined together, because the least dampness will cause them to start from their frames.

"But, still worse, some have tried to reproduce in carpentery forms which are proper in a material that is not fibrous, and belong to a bulky material like stone or marble: columns, entablatures, and round pediments have been made in carpentry with parts or pieces glued or fastened together contrary to the properties of wood; some articles are turned by the lathe, although on account of its fibres, which are parallel to each other, wood permits the use of only flat or straight forms. If you look through works on carpentery, you will find that authors recommend wood to be used in ways contrary to its nature; that they think that their extravagances are the triumphs of art, or, to use a common expression, masterpieces.

"These strange manias are, it is true, of recent date,

but they exert a powerful influence. Those who, on account of them, have abandoned the rules of common-sense and reason, pretend to class those who know how to conform to them while producing charming works, as rude artists.

"You will see many others in the practice of our industries connected with carpentry, iron, cabinet, bronze work, &c. You have often heard the word *style.* People say a certain work of art has style, or another lacks it. Why is it? The works of art always bear the mark of style when the author respects the elements of which they are composed.

"Let me explain:

"Style may be found in a jug, or a piece of furniture, as in a building, or a statue, or a painting, if only the artist has reasoned out the design, form, and the essential conditions, which in objects are their purpose, nature, and the properties of their material; or, in statuary or painting, the principal character of the individual or subject.

"Nature always gives style to her productions, because she proceeds logically, both in the organic and inorganic series, adopting the forms which are the result of a purpose.

"When in any of our industries it is necessary to create, or make an article, it is well to proceed as Nature herself does, and take into account the purpose of the article, and the qualities of the material out of which it is

fashioned. An earthen or glass vase should not have the form belonging to one made of silver or bronze, and a piece of iron furniture should not resemble one made of wood. This is why it is well to perfectly understand the various industrial processes, so as not to deviate from them in designing objects supplied by them."

For some months Jean practised the designing of articles of widely different forms, and was obliged to point out the means by which he was to execute them, which did not prevent him from drawing from the living model. When M. Majorin examined his pupil's studies, he always insisted that he should express the character proper to each individual, giving him to understand that there was harmony in the face of each, and that the gestures, attitudes, and conformation of the bones and muscles, as well as the face, possessed an individual character.

Jean was in the habit, whenever attracted by a face, of impressing it on his memory, and trying to reproduce it (Fig. 109); or he practised the copying of animals, and tried to introduce their forms into his compositions; or he analyzed plants, and their organs, and found in them charming elements for new forms, and subjects for the nicest observations, by which he profited. He observed every day that the artists of antiquity, like those of the middle ages, proceeded in the same way.

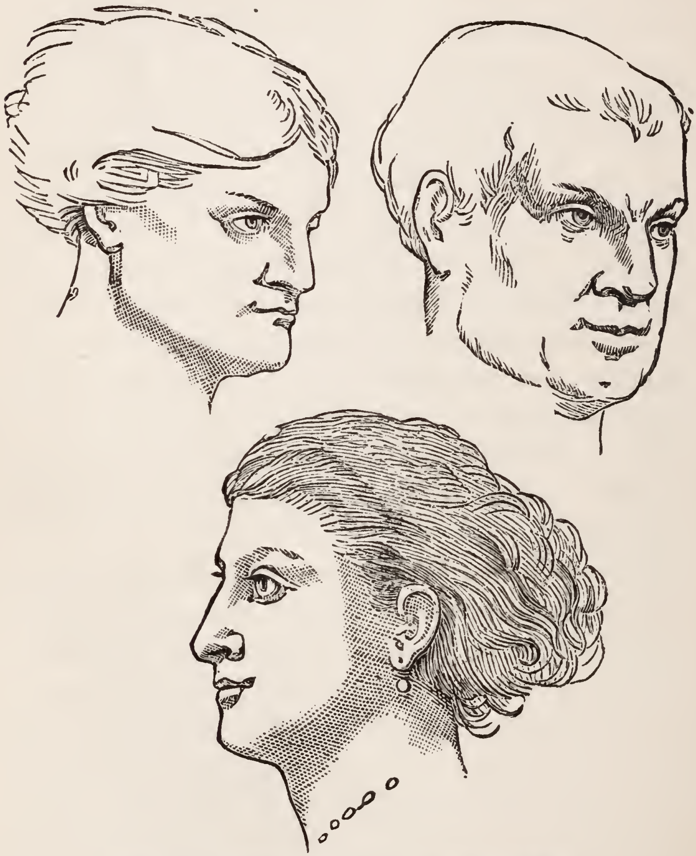


FIG. 109.—SKETCH OF VARIOUS TYPES AND FACES.

This was very good practice, as it accustomed him to distinguish the principal features at once, and those peculiar to each individual, which is the first condition of style.

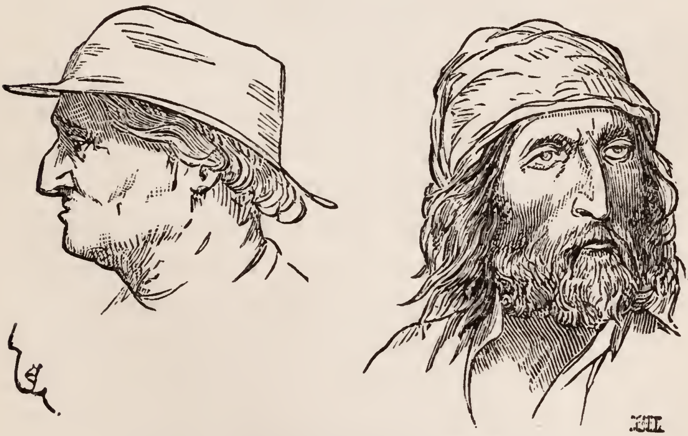


FIG. 109 A.—SKETCH OF VARIOUS TYPES AND FACES.

CHAPTER XIX.

DIFFICULTIES IN THE WAY.

ONE morning a friend, a manufacturer to whom he had applied, and who was to help start on a new plan shops for the sale of Parisian goods, called at the house of M. Majorin.

This early visitor was a person of influence, who had been decorated at the close of one of the recent exhibitions, and was the president of several commissions.

"We are progressing," he said, sitting down: "we are progressing! our special school is ready, and in the shops of many of our colleagues preparations have been made to adopt new models. But we must not neglect our patrons. You know how unwilling the public is to accept any innovation. A great authority in arts, having heard of our project, came to see me one day. He has under his care a young pupil from the School of Fine Arts, a very distinguished scholar, who, as an architect and skilful designer, came near winning the Roman prize; but

who, not daring on account of his limited means to run any risk of failure in the long struggle of an architect's career, would be disposed to devote his talent to manufacturing, and" —

"And what?"

"And this same noted person wished to say, that if we placed this young man at the head of our enterprise we should be assured, now and henceforth, of a good patronage from his colleagues and from fashionable society."

"That seems to me a good idea. Is this young man acquainted with the various manufactures in which he will be engaged?"

"I do not know about that."

"And is he fitted, though a good draughtsman, to furnish designs suitable to the numerous branches of this manufacture?"

"Probably."

"Probability is not certainty: has he seen much?"

"I cannot say."

"Does he know of what bronzes are made? and does he know much about wood, — has he seen it used? Does he know how iron is forged and welded, and how it is silvered and gilded? how metal is laid on metal? how marquetry is made, and ivory worked? Does he know any of the principles of mechanics? Does he know how clay or metal is enamelled, how glass is worked, and how to paint on china? Has he acquired a knowledge

of chemistry, mineralogy, and physics? Has he learned all this in the School of Fine Arts?"

"You require a great deal of him."

"I ask nothing more than what we need."

"This young man, who is called very intelligent, will quickly learn this."

"At your expense, I imagine."

"Only until he becomes a good designer."

"Designer of what? The commonplace you wish to avoid. It is not enough to skilfully handle the pencil or brush, but one must design on account of the various kinds of manufactures which require patterns."

"Certainly, certainly; but if, on the other hand, we have the support of all the people of taste who occupy good positions, and if we are thus certain of disposing of our productions (and it seems that this young man has influential friends), it matters little that we make sacrifices to teach our designer his trade."

M. Majorin would have liked to throw his questioner out of the window: after having spent ten years in preparing a candidate, who was naturally gifted; after cherishing the single resolve to place in his hands the very instrument by which he could work out a career whose importance and usefulness he foresaw; and to find himself checked, as he neared his goal, by a common obstacle, a mere question regarding a person or place!

But M. Majorin had long been accustomed to these

drawbacks: he therefore did not throw the honorable visitor out of the window, but simply said, —

"But, my dear sir, I thought we understood each other on the principal point, a question of principle which ought to overrule all other considerations; namely, that our organization should endeavor to depart from the path which we have long followed, which you, and all our colleagues who were consulted, believe will lead to a decline in those of our industries which are most intimately connected with the arts, if we do not energetically bring a remedy for the present situation.

"Do you propose to place our attempts at reform in the hands of those who have constantly repulsed them, and who do not in the least desire that *industrial art*, as they call it, should take its place by the side of art, — of the *great art;* since it is agreed that there is a great art and a little art?"

"Agreed. But if we at first alienate the men who have influence in matters of art, and from whose judgment there is no appeal, do we not run the risk of losing all our efforts, and producing works that will remain unsold in our shops? for you know better than I how important it is to be sustained in an enterprise which tends to modify habits acquired by the public."

"This cannot be denied; but, if we undertake to reform these habits, we should not address those who are interested in preserving them. What you propose, far

from ameliorating the present state, would tend, on the contrary, to make it worse; for now, at least, though we are guided by chance, it may aid us as it has in the past; but, if you put yourself under the lead of artists whose principles are diametrically opposed to those we would establish, we might as well continue, as in the past, without following a principle, and making imitations that are more or less successful, and satisfy the caprices of fashion with varying results."

These reasons did not seem to convince M. Majorin's friend, and they separated without coming to a decision.

Jean, who was working in the next room, now appeared, and said to his teacher, —

"I must confess, sir, that I have unwillingly heard all that you and M—— have been saying; and, as well as I can understand it, I think it would be very difficult, after this, for you to secure the position for me against the will of those gentlemen.

"If you will consent, I will therefore enter a very humble shop, whose proprietor has offered to let me manage it; and I will not seek a higher position. There I will work, and I think I can make myself useful. If I am able, as I hope, to make use of what you have taught me, I shall succeed in something later. You have always talked to me of difficulties and obstacles to be overcome. But until to-day you spared me the trial. It is my turn to show you, thanks to yourself, that I can bear them firmly. Therefore allow me to enter this shop."

"You are a worthy fellow, Jean, my dear boy, and perhaps what you say is the best that can be done. But do not be in a hurry: I will manage the conditions of your co-operation. This manufacturer is young and very intelligent. He began in a small way, being formerly a simple workman. His house has constantly grown on account of the care he has exercised to sell only an excellent quality of goods.

"He is always studying, and needs only elementary knowledge which you can give him. I will see him the day after to-morrow. But," he added, as if talking to himself, "it is always thus everywhere. Must not our country have great strength to produce any thing passable in spite of the difficulties it has constantly to overcome? These are the men to whom we must have recourse, for they are the masters. They not only scorn industrial art, but do not grant it a place by the side of what they call art, and exclude it from the regular exhibitions (as if a piece of furniture or a well-designed and well-made vase were not worth as much as a wretched picture or a poor statuette). Then if, by chance, private individuals agree to elevate this industrial art, the source of prosperity to the country, whose capacities and means of using them these contemptuous men have never studied, 'It may be excellent,' they say, 'but we must manage it.' Well, we will not think of it any more. I was too innocent to suppose that in the present state we could try any thing else."

It came about as we have intimated: Jean (whom we can no longer call little Jean) was put at the head of the shop of this humble furniture-maker. The latter, who was a skilful workman, and already well known to a limited circle of patrons for his honesty and regularity in business, found the necessary funds; and Jean set up machinery which enabled them to economize time and material. He devoted himself in particular to manufacturing furniture of iron and wood which joined elegance to great durability, and understood how to give these materials the form appropriate to their qualities. Patents were taken out; and several amateurs of taste, charmed by the novelty and originality of the designs, gave large orders. At one particular exhibition at the Champs Elysées, several pieces of this furniture were greatly praised. The house soon had more orders than it could fill, and enlarged its business. The use of bronze was added to their work; and, later, attention was given to the use of inlaid metals. All the patrons of the establishment were eager to have dealings with Jean, who readily understood their plans, and always met their wishes, anticipating what they expected, and overcoming every difficulty. The ease with which he expressed his ideas in a sketch, and the knowledge which he acquired and extended every day through his habit of observation, and of testing every thing, attracted the attention of several scholars and liberal-minded men. They consulted him

many times; and he always gave clear answers, dictated by good sense and practice, to their questions. In odd moments he continued to study and to perfect his taste. The nature of his studies also fitted him to build, decorate, and furnish a house.

This was very convenient for many, particularly foreigners, who, being unable to reside in France, remained only a few months.

As Jean was accurate and careful, they trusted him with their contracts, feeling sure they would be successfully carried out within the time agreed upon.

M. Majorin fully enjoyed the success of his pupil, who began to reach a fine position in the industrial world, and had plenty of brilliant offers.

The attempt to educate in industrial art by means of workshops failed, as might have been anticipated.

The distinguished manufacturer of whom we spoke at the beginning of this chapter said to M. Majorin one day,—

"Why did you not tell us that M. Jean Loupeau was so qualified to be at the head of the organization we were planning?"

"What! I present an unknown young man to you when you came with a quasi-laureate from the Institute? No, indeed!"

"But you might have told us something about him."

"'Never,' you would have answered me. 'You are an interested person.' I made the young man what he is,

and could not force him upon you. But what have you done with your quasi-laureate from the Institute?"

"Nothing."

"Nothing? that is very little."

"He understood nothing about manufacturing, and furnished us designs that were very beautiful on paper perhaps, but thoroughly impracticable."

"You used to say that after several attempts he would soon understand the practical part of your business."

"He did not, however. To our remarks he made but one answer: 'It is not for art to submit to material methods, but material methods should yield to art.' He persisted in following this maxim."

"Did he, indeed?"

"So much so, that, after spending considerable money without making a cricket or a candlestick, we wound up the business."

"And where were the influence and patronage promised you?"

"Oh! we could manufacture nothing with what that gentleman gave us."

"It is a pity. *Au revoir.*"

CHAPTER XX.

CONCLUSION.

JEAN LOUPEAU, it is said, is following the plan of M. Majorin. Being well known to-day by the principal manufacturers of Paris, he thinks of organizing there a school and apprentice-shop for those very important branches of industry whose decline would be a calamity to the country. M. Majorin has retired from business: but his active mind is always ready to come to his pupil's aid; and he lives near him, for he really looks upon him as his child.

M. Mellinot died after having lost the greater part of his savings in bad investments, and without having received the cross of the Legion of Honor, for which neglect Mme. Mellinot will never forgive the government.

As for André, whom we have lost sight of for some time, after trying many things which led to nothing, although he was pretty successful in his studies, he obtained a situation with a railroad-corporation through the

agency of Jean and his friends, who, like the latter, had graduated from the Central School.

Jean's father and mother still live at Boissy-Saint-Léger. The house in which they live is their own, having been bought by Jean with his first savings. M. Majorin gave a dowry to one of the sisters of his pupil, who took it upon himself to dower the other. As for the brothers, one is a carpenter, one a soldier, and the youngest two are excellent apprentices in the shops directed by Jean. They are all happy and well settled in life, because little Jean took it into his head to draw a cat. This is only one-half of the moral of this true story.

This is the other: —

Drawing, taught as it should be, and as M. Majorin took pains to teach it to Jean, is the best way to develop the mind and form the judgment; for thus one learns to see, and to see is to know.

INDEX.

K.

L.

M.

N.

O.

P.

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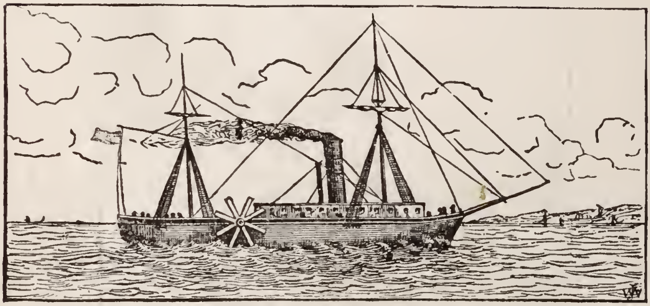

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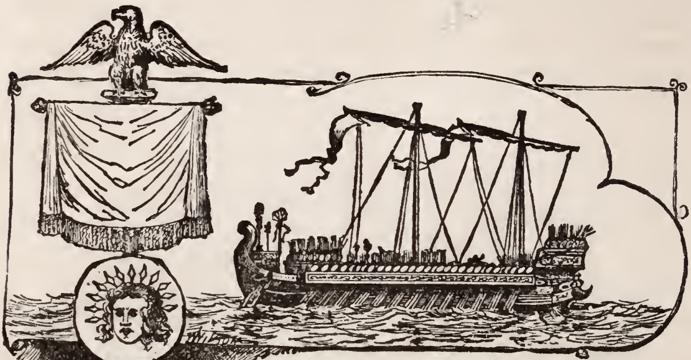

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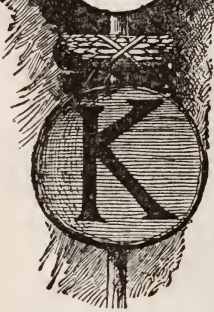

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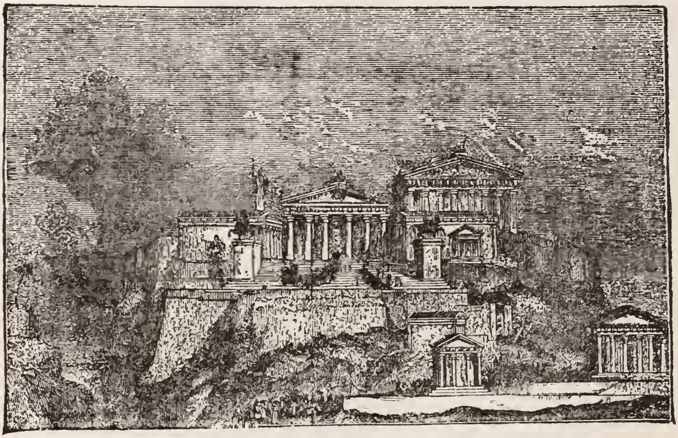

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